JOURNAL OF DAIRY SCIENCE

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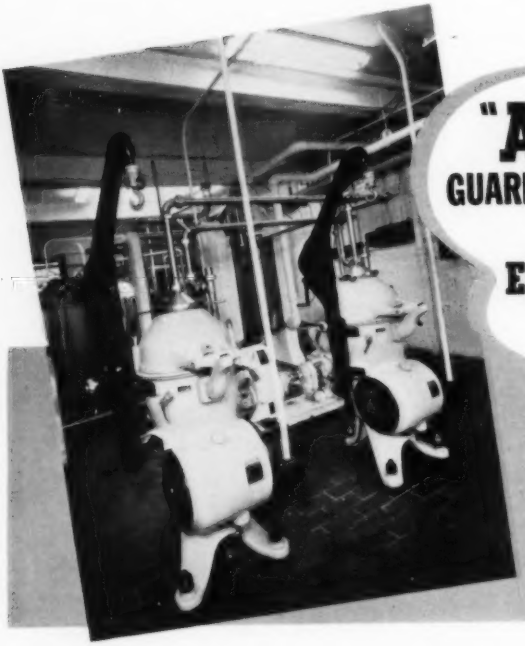

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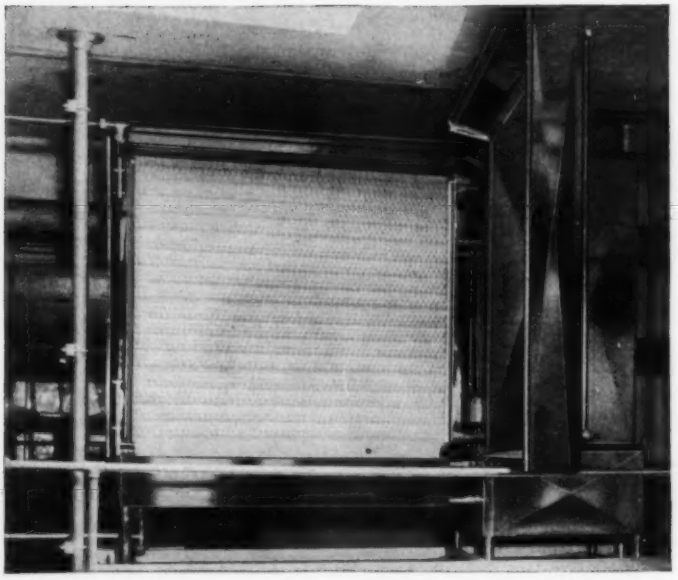

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JOURNAL OF DAIRY SCIENCE

VOLUME XXIV APRIL, 1941 NUMBER 4

OXIDIZED FLAVOR IN MILK. VIII. THE EFFECT OF THE DEGREE OF SATURATION OF FAT IN THE RATION OF THE COW UPON THE IODINE NUMBER OF THE BUTTER FAT AND THE SUSCEPTIBILITY OF THE MILK TO METAL-INDUCED OXIDIZED FLAVOR

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West Virginia Agricultural Experiment Station, Morgantown

Feed was one of the earliest factors known to influence the susceptibility of milk to oxidized flavor. Kende (6) in 1932 reported that oleaginous (oxidized) flavor in milk seemed to occur only during the winter, and that green feed as well as fresh hay contained considerable amounts of reducing substances which tended to prevent oxidized flavor from developing. Stebnitz and Sommer (8) studied the effect of the composition of butter fat on its susceptibility toward oxidation. They found the stability of a fat toward oxidation bore an inverse relationship to the degree of unsaturation of the fat, with linoleic acid content rather than oleic acid the principal governing factor. When cows received grass as part of their ration, the butter fat became less saturated and more susceptible to oxidation. It appeared that protective substances prevented the development of oxidized flavor. Dean and Hilditch (3) found that when cows went on grass there was an abrupt increase in the oleic and linoleic acids and a parallel reduction of butyric and stearic acids in the butter fat.

Prewitt and Parfitt (7) found that rations containing soybean oil, either as such or in the unprocessed beans, have a tendency to produce milk which upon holding developed less intense oxidized flavor than did milk from cows fed other rations. Corbett and Tracy (2) studied the effect of adding cocoanut oil and corn oil to the ration and found that changing the degree of saturation of the fat had no effect on the development or occurrence of oxidized flavors. Gould, Fox, and Trout (4) found no relationship between the susceptibility of milk to copper-induced oxidized flavor and the lecithin content of the milk.

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[1] Department of Dairy Husbandry.

[2] Department of Agricultural Chemistry.

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Although evidence has been submitted (1, 9, 10) that oxidized flavor is not the result of the direct oxidation of the fat itself, it is possible that the degree of saturation of the fat may play a part since milk contains a delicate oxidation-reduction system. The degree of saturation of the fat may affect this system.

In order to obtain information on this point the following experiment was planned and conducted.

EXPERIMENTAL

For use in this experiment, eleven cows whose milks were susceptible to oxidized flavor when contaminated with copper, were selected and placed on a ration low in fat. The ration consisted of a grain mixture of 300 pounds oats, 300 pounds barley, 300 pounds wheat bran, 15 pounds salt, and 10 pounds bone meal, with brown alfalfa hay and beet pulp as roughage.

Samples of milk were collected from each cow each morning and pasteurized in bottles. Following pasteurization the samples were divided into two lots and one lot was contaminated with copper at the rate of none, 0.5 p.p.m., 1.0 p.p.m., and 1.5 p.p.m. of copper added from a solution of copper sulphate. These samples were then stored in ice water for three days, after which they were scored by at least three judges familiar with oxidized flavor. The milk from Lot 2 was composited for two days and churned. The butter thus obtained was melted and centrifugalized in Hart's casein tubes in an electrically heated centrifuge for 15 minutes, after which the clear liquid butter oil was decanted into a clean dry jar, care being taken not to pour off any water or curd collected in the base of the tube. The samples then were ready for iodine number determination. All iodine numbers were determined in duplicate by the Hanus method. Two samples were obtained each week from each cow.

After a preliminary period in which the normal variations in flavor and iodine number from day to day were determined, the cows were divided into two groups, group one to receive the oil supplements, while group two acted as a control. Each cow in group one received a supplement of one pound of oil per day in addition to the ration which they were already receiving. Four types of oil were fed. Cocoanut oil, which supplied a relatively large proportion of the saturated, shorter-chain fatty acids, was fed to cows No. 447 and 452. Crude soybean oil, supplying a high percentage of longer-chain unsaturated fatty acids and a small percentage of lecithin, was fed to cows No. 462 and 463. Refined soybean oil, similar to the crude product except that the lecithin had been almost entirely removed, was fed to cows No. 477 and 478. Hydrogenated soybean oil, a refined soybean oil which had been hydrogenated to give long-chain highly saturated fatty acids, was fed to cows No. 480 and 491. This experimental feeding was continued for six weeks, after which time reversals in feeding were made. The results of

this experiment are shown in table 1. An examination of the averages obtained during this period of feeding as compared with the preliminary period shows, except in one instance, that as the iodine number of the butter fat increases the intensity of the oxidized flavor increases, and as the iodine number decreases the intensity of the oxidized flavor decreases. The oxidized flavor values recorded in this table were obtained by averaging the flavor values from all three copper concentrations for the two days. This gave flavor values comparable to the iodine absorption numbers of the composite fat samples for the same period.

During this period it was found that the crude soybean oil was not as high in natural lecithin (phosphatides) as we had hoped to obtain so a supply of expeller soybean oil was obtained and substituted for the crude soybean oil in the reversal trials. The chief difference between the expeller oil

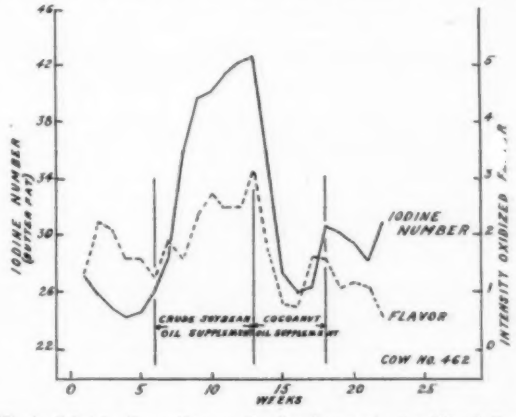

FIG. 1. Effect of fat in the ration on the development of oxidized flavor in milk.

and the crude soybean oil is that the expeller oil is higher in lecithin (phosphatides) content. In making the reversals the change was made so that each individual of any given group received a different type of oil. The effects of this reversal on both the iodine number and the flavor of the milk are shown in the latter part of table 1. These results show quite clearly the effect of the oil supplement on the iodine number of the resulting butter fat. With the exception of the hydrogenated soybean oil the iodine number of the butter fat tended to parallel the iodine number of the fat supplement. In this case the cow apparently desaturated the fat and the resulting butter fat had a slightly higher iodine number than was expected. The relationship between iodine number of the butter fat and the development of oxidized flavor does not readily appear from an examination of table 1. However, when these data are plotted in graph form (figures 1, 2, 3 and 4) it appears evident that as the iodine number increases the intensity of the oxidized

TABLE 1

The effect of oil supplements to the ration on the iodine number of the butter fat and on the development of metal-induced oxidized flavor

Preliminary Feeding

	Cow number															
	447		452		462		463		477		478		480		491	
	Iodine number	Flavor*	Iodine number	Flavor	Iodine number	Flavor	Iodine number	Flavor	Iodine number	Flavor	Iodine number	Flavor	Iodine number	Flavor	Iodine number	Flavor
	28.86	1.00	26.06	1.00	26.90	1.50	27.89	0.83	26.40	0.33	30.36	0.50	28.72	0.66	30.00	3.66
	30.91	0.66	26.24	2.17	27.76	1.17	28.85	1.84	26.95	1.33	29.90	0.66	29.20	1.50	31.55	2.50
	27.55	1.00	25.28	1.17	25.76	2.33	26.92	1.66	26.69	1.50	28.86	1.00	27.83	1.50	25.03	2.66
	25.37	0.66	24.01	2.66	25.91	2.17	27.43	2.66	24.98	1.84	27.65	0.84	27.54	2.66	27.43	3.17
	28.52	0.84	23.70	1.50	25.75	2.00	26.82	3.00	24.93	0.66	27.63	1.00	26.87	2.00	26.74	2.00
	25.70	2.00	22.23	1.66	24.07	2.17	25.44	2.00	23.24	1.17	25.40	1.17	26.74	3.66	27.01	3.17
	23.95	2.00	23.14	2.50	24.81	1.84	26.00	2.66	23.79	2.00	26.47	1.66	27.47	4.33	27.91	3.33
	22.91	0.66	23.10	2.33	23.64	1.33	25.32	1.84	23.87	1.33	26.00	1.50	26.65	3.00	26.22	3.17
	23.40	1.33	23.14	2.17	24.39	1.66	26.26	2.84	23.48	0.66	26.94	1.50	27.38	3.84	27.73	4.17
	26.74	1.50	24.63	2.84	24.93	1.50	26.68	3.84	24.19	1.84	28.67	2.33	27.23	3.50	28.78	4.00
	24.10	1.33	24.14	1.50	26.70	1.33	26.97	2.84	24.93	1.17	28.72	1.66	27.34	2.84	28.01	2.00
	23.56	1.00	24.22	1.66	25.49	1.17	25.77	2.17	24.32	1.00	26.98	1.33	27.58	3.33	29.14	3.33
	24.38	1.17	25.23	2.84	27.19	2.00	27.90	3.50	26.20	1.17	30.13	2.00	27.12	3.33	32.29	2.84
Average	25.84	1.17	24.22	2.00	25.64	1.71	26.79	2.44	24.92	1.23	27.98	1.32	27.51	2.78	28.30	3.08

	Oil Supplement															
	Cocoanut oil				Crude soybean oil				Refined soybean oil				Hydrogenated soybean oil			
	22.18†	1.84†	21.06†	1.17†	29.79†	1.84†	41.26†	3.84†	36.77†	4.33†	38.53†	3.66†	29.45†	2.00†	30.34†	2.33†
	21.65	0.33	21.48	1.84	35.25	2.00	41.31	4.17	40.94	3.84	40.58	3.00	29.61	2.66	28.92	2.17
	23.72	1.17	22.33	0.17	36.30	1.17	41.66	3.84	39.15	3.66	41.60	2.33	31.02	2.17	33.75	1.50
	22.61	0.00	22.13	0.33	38.62	2.00	44.92	3.66	40.30	3.50	43.42	1.84	33.49	1.17	33.94	1.00
	23.52	0.17	22.40	2.00	40.67	2.66	34.78	3.50	41.50	4.00	45.35	2.50	32.03	1.84	32.15	1.00
	24.44	0.17	23.91	0.50	40.10	2.84	48.29	4.17	43.50	2.66	48.93	2.50	33.41	2.00	31.31	1.00
	24.06	0.00	24.53	0.00	39.77	2.66	49.69	4.33	44.22	1.00	46.90	3.66	35.49	1.66	33.57	1.66
	22.52	0.00	23.77	1.33	41.10	3.00	50.31	2.84	42.10	3.84	49.35	3.50	32.33	2.33	31.61	3.17
	23.99	0.17	24.28	0.50	41.64	2.17	52.06	3.33	46.01	3.17	50.77	4.66	33.74	1.84	34.22	3.00
	24.47	0.33	24.00	0.33	42.53	2.00	52.87	3.17	46.45	4.17	51.55	3.66	33.22	3.00	32.77	3.00
	23.97	0.50	23.40	0.33	41.61	3.17	50.73	3.33	44.27	3.66	50.27	2.33	34.62	3.84	33.61	2.66
	23.86	0.33	23.55	2.00	42.03	3.00	49.17	3.33	42.76	3.33	49.76	2.17	34.48	3.50	33.00	3.66
	22.06	1.33	23.05	1.50	42.91	3.33	49.40	3.00	44.40	3.66	48.19	2.00	34.11	3.84	32.08	2.17
Average	23.31	0.49	23.07	0.92	39.41	2.45	46.65	3.58	42.49	3.45	46.55	2.91	32.85	2.45	32.41	2.18

TABLE 1—(*Continued*)

Oil Reversal

	Cow number															
	447		452		462		463		477		478		480		491	
	Iodine number	Flavor*	Iodine number	Flavor	Iodine number	Flavor	Iodine number	Flavor	Iodine number	Flavor	Iodine number	Flavor	Iodine number	Flavor	Iodine number	Flavor
	Expeller soybean oil		Refined soybean oil		Cocoanut oil		Hydrogenated soybean oil		Cocoanut oil		Hydrogenated soybean oil		Expeller soybean oil		Refined soybean oil	
	26.53†	1.00†	28.92†	2.50†	40.31†	2.50†	44.10†	4.33†	37.12†	4.33†	48.01†	1.66†	40.07†	1.84†	38.09†	3.84†
	40.03	0.84	40.78	1.84	28.91	0.84	34.94	1.84	27.89	1.00	41.52	0.50	49.62	3.66	48.96	3.17
	41.42	1.17	40.22	1.66	26.79	0.66	31.96	2.17	27.48	0.66	35.42	1.33	47.17	3.66	49.48	3.17
	41.61	0.66	43.16	1.33	28.03	1.00	32.22	2.66	25.15	0.33	35.18	1.00	50.98	3.66	51.50	3.50
	45.94	2.50	43.84	1.66	25.70	0.84	31.86	1.00	26.60	1.00	33.64	0.66	50.99	2.33	49.12	3.66
	43.99	1.84	44.96	2.33	26.50	0.66	30.02	2.66	24.97	0.50	32.27	2.66	52.01	2.33	51.12	3.66
	42.52	2.66	43.40	2.00	26.28	1.17	28.19	2.00	25.71	0.66	32.89	1.50	45.90	2.33	49.38	3.66
	36.28	2.00	42.86	1.66	26.55	2.17	35.69	1.66	25.82	0.50	32.24	1.50	48.31	3.66	47.53	2.84
Average	39.79	1.58	41.02	1.87	28.63	1.23	33.62	2.29	27.59	1.12	36.40	1.35	48.13	2.93	48.15	3.43
	Readjustment Period															
	32.79†	1.50†	33.61†	2.33†	30.28†	1.50†	lost	lost	28.92†	1.00†	31.50†	1.00†	36.74†	3.00†	35.51†	2.17†
	28.30	1.00	29.06	2.66	30.89	1.66	29.82	2.84	28.24	1.50	30.58	2.00	34.76	3.17	37.94	2.50
	26.25	1.84	28.79	2.17	30.77	1.66	30.18	1.50	28.25	2.17	30.91	1.00	33.40	3.00	32.02	2.17
	27.81	1.00	28.58	3.17	29.58	0.50	29.53	2.66	30.38	1.66	28.93	1.50	31.29	0.84	32.10	3.00
	26.67	1.00	28.13	1.66	29.84	1.17	30.38	1.66	27.14	1.33	30.42	0.84	31.12	2.66	sold	sold
	26.19	1.50	28.38	2.66	29.25	1.17	28.88	2.17	26.30	0.33	31.07	0.84	31.00	2.66		
	25.98	1.33	28.04	1.84	28.88	2.17	29.35	2.66	28.91	0.17	31.93	1.00	33.60	2.50		
	25.39	0.00	26.57	1.33	27.77	0.00	28.93	2.17	25.84	1.17	30.88	0.84	32.21	2.00		
	26.55	0.50	28.37	0.33	30.01	0.84	29.37	2.84	28.91	0.17	31.93	1.00	33.60	2.50		
	29.68	0.50	32.80	0.84	31.95	0.33	33.23	1.84	34.92	0.17	35.80	1.33	38.07	1.50		
Average	27.56	1.02	29.23	1.90	29.92	1.10	29.96	2.26	28.78	0.97	31.40	1.14	33.58	2.38	34.39	2.46

* Oxidized flavor intensity as reported in previous work. JOUR. DAIRY SCIENCE **22**: 31. (1939).

† Transition values.

flavor increases. In figure 4 this relationship is uncertain due to wide flavor fluctuations. When hydrogenated soybean oil is supplemented to the ration the iodine number of the butter fat increases. This probably was due to the ability of the cow to desaturate the saturated fat. This same phenomenon

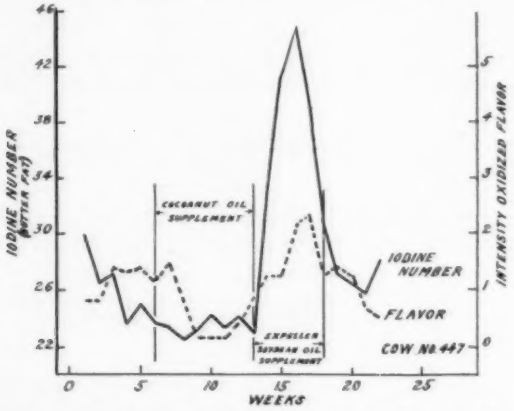

FIG. 2. Effect of fat in the ration on the development of oxidized flavor in milk.

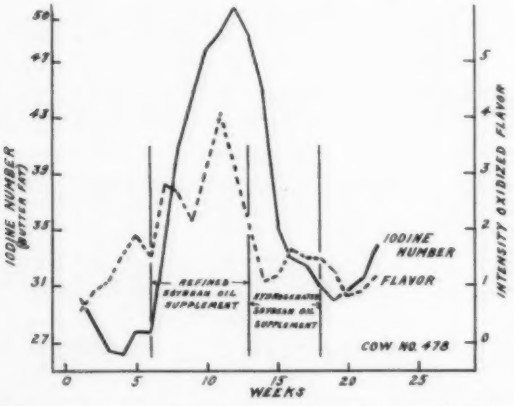

FIG. 3. Effect of fat in the ration on the development of oxidized flavor in milk.

occurred in the case of cow No. 480 on this supplement. Apparently it is the iodine number of the fat in the ration and not the degree of saturation of the butter fat that influences the susceptibility of the milk to metal-induced oxidized flavor.

The relationship between the iodine number of the oil supplement in the ration and the iodine number of the butter fat is shown in table 2.

The cocoanut oil supplement which was high in short-chain fatty acids

and had an iodine number of 11.2, gave butter fat with an average iodine number of 24.2 as compared with 28.1 as the average iodine number on the same ration without the oil supplement. The expeller, crude, and refined, soybean oil supplements all had an iodine number of approximately 127 and the resulting butter fat from the supplements all had an average iodine

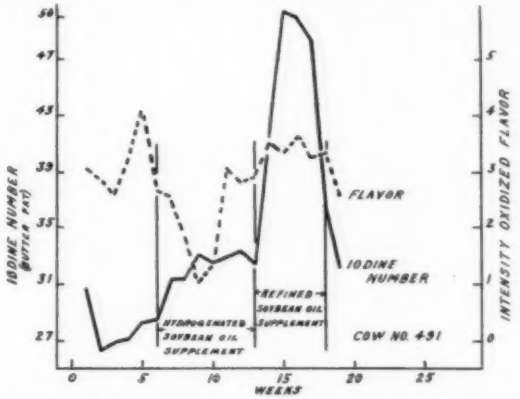

FIG. 4. Effect of fat in the ration on the development of oxidized flavor in milk.

TABLE 2

The relationship of iodine number of oil supplement in the ration to the iodine number of butter fat

Oil supplement	Iodine number of oil supplement	Butter fat			
		Number of samples	Range of iodine numbers		
			Highest	Lowest	Average*
No supplement	.....	160	38.1	22.2	28.1
Cocoanut oil	11.2	38	38.9	21.5	24.2
Expeller soybean oil	126.7	12	52.0	36.3	45.6
Crude soybean oil	127.5	12	52.9	35.3	43.7
Refined soybean oil	126.6	38	51.6	39.2	45.7
Hydrogenated soybean oil	17.4	38	35.5	28.2	33.5

* All transition values excluded.

number of approximately 45. These supplements were high in the longer-chain unsaturated fatty acids. In addition to this the expeller oil contained 4.20 per cent phosphatides calculated as lecithin whereas the crude soybean oil contained 1.91 per cent and the refined soybean contained .061 per cent. The hydrogenated soybean oil contained .028 per cent lecithin whereas the cocoanut oil contained .035 per cent lecithin. The phospholipids were determined by the method outlined by Horrall (5) and the lecithin calculated from the phosphorus. From these results so far as could be determined by inspection the percentage of lecithin in the oil supplement had little or no effect on the susceptibility of the milk to metal-induced oxidized flavor. The

TABLE 3

Variations in iodine-number of milk fat and in metal-induced oxidized flavor of milk from control cows on a low-fat ration during periods corresponding to that of the oil-fed group

Cow number	374		385		441	
Corresponding period	Iodine number	Flavor*	Iodine number	Flavor*	Iodine number	Flavor*
			27.66	1.33	27.59	1.84
			28.66	1.84	26.41	1.17
	29.27	3.66	27.94	2.66	27.56	1.84
	31.63	3.00	27.07	2.66	28.30	1.84
	27.24	1.50	27.25	1.84	25.27	2.66
	24.34	0.66	28.51	2.84	24.84	1.84
Preliminary	22.96	0.66	29.24	2.00	26.69	1.33
	24.75	0.84	28.63	3.00	24.88	1.50
	27.24	1.50	27.17	1.50	26.58	2.66
	20.51	1.00	29.86	2.33	25.57	2.66
	19.71	1.00	28.38	2.00	24.47	2.33
	18.99	0.33	29.00	2.00	25.41	2.84
	20.22	1.50	29.42	2.66	25.55	2.00
Average	24.26	1.42	28.37	2.20	26.09	2.04
	21.50	0.17	29.76	2.00	26.77	2.00
	21.51	0.00	29.41	2.50	25.04	1.33
	21.43	0.33	29.00	1.84	27.02	3.33
	29.03	0.50	29.72	3.33	28.70	3.17
	27.38	0.66	27.98	0.66	27.25	2.00
	25.45	1.00	30.90	1.50	27.21	2.50
Oil feeding	25.26	0.33	31.01	2.00	27.02	2.66
	22.64	1.33	29.23	1.66	26.47	2.33
	22.20	1.00	29.38	2.33	25.98	2.33
	28.23	0.84	30.27	3.50	26.03	2.33
	24.01	0.33	30.63	2.50	27.01	4.84
	23.58	0.17	30.74	2.84	25.10	3.17
	24.16	0.33	30.99	2.00	26.34	2.50
Average	24.34	0.54	29.92	2.20	26.61	2.65
	23.31	1.00	31.12	4.33	28.37	3.84
	22.94	1.00	31.13	2.00	28.18	3.66
	22.76	0.50	30.47	1.50	25.76	2.66
	22.71	0.33	30.45	2.66	26.24	2.33
Oil reversal	23.77	0.00	31.59	1.17	26.16	0.66
	22.93	1.17	31.22	2.66	41.25	1.00
	21.96	0.33	30.17	1.84	35.07	0.17
	22.05	1.84	30.87	2.33	27.89	2.33
Average	22.80	0.77	30.88	2.31	29.87	2.08
	23.02	1.17	33.28	0.50	27.49	1.00
	23.06	0.66	31.10	1.50	27.92	0.66
	21.82	0.17	30.66	1.00	27.53	2.84
Readjustment	32.16	0.17	31.66	1.00	29.06	3.00
	22.38	0.00	32.16	0.33	28.22	3.00
	23.25	0.50	31.80	1.33	28.97	4.00
	24.12	0.33	31.53	0.33	30.35	2.66
	22.84	0.00	31.38	1.66	29.71	3.00
	26.26	0.00	35.62	0.50	28.99	1.33
Average	24.32	0.33	32.13	0.91	28.69	2.39

* See Table 1 footnote.

hydrogenated soybean oil supplement which is comparable with the refined soybean oil except that the iodine number had been reduced to 17.4 by hydrogenation, resulted in butter fat with an average iodine number of 33.5, compared to 28.1 for butter fat produced without an oil supplement. This indicates that the cow can desaturate the fat during the metabolic process.

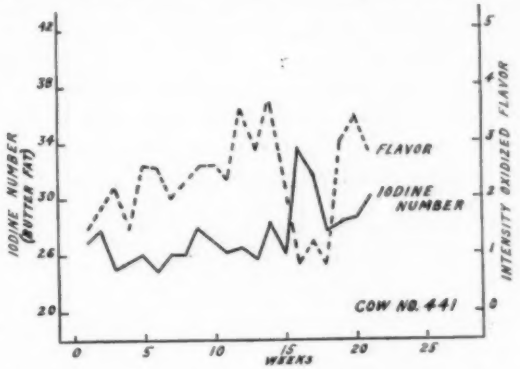

FIG. 5. Variations in iodine number of butter fat and in metal-induced oxidized flavor of milk from a control ration.

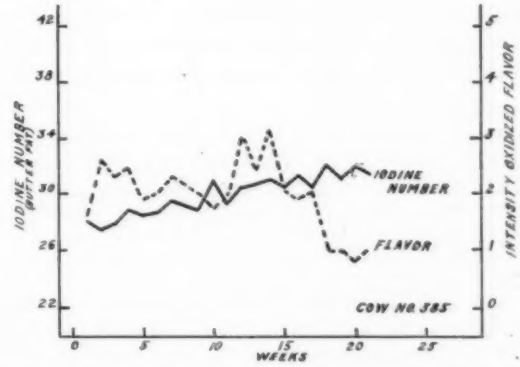

FIG. 6. Variations in iodine number of butter fat and in metal-induced oxidized flavor of milk from a control ration.

The relationship between iodine number fluctuation and the intensity of metal-induced oxidized flavor on a normal ration is shown in figures 5 and 6 and in table 3. An inspection of these data reveals that small changes in iodine number of the butter fat has little influence on the intensity of metal-induced oxidized flavor in milk. Apparently, it is of minor importance when compared to other factors.

DISCUSSION OF RESULTS

The results obtained in this experiment indicate that there is a direct relationship betwen the iodine number of the fat in the ration and the intensity of metal-induced oxidized flavor developed in the milk. As the iodine number of the butter fat increases the intensity of the oxidized flavor increases. This does not follow in the case of feeding hydrogenated soybean oil. In this case the cow apparently desaturates the fat in the ration and the iodine number of the butter fat increases over that of a normal ration. The hydrogenated soybean oil was very laxative while the other oils did not display this tendency. The results obtained from the control cows on a low fat ration indicate that there is little correlation between the iodine number of the butter fat and the intensity of metal-induced oxidized flavor developed in the milk. Apparently other factors are much more important and their fluctuation obscures any relationship which might exist.

The results obtained in this experiment are not in agreement with those of Corbett and Tracy (1), but in their work the trials were conducted for a period of 10 days, followed by a 10-day readjustment period prior to a 10-day reversal in type of oil. During a major part of that time the animals were not receiving as large a supplement as in the present experiments. In our experiments the cows were maintained on the oil for a period of seven weeks followed by a five-week reversal in type of oil. Under these feeding conditions of one pound of oil per cow per day it required approximately three to four weeks for the iodine number of the butter fat to reach a maximum change. This is a somewhat longer period than has been reported previously.

Other interesting conditions are the range in fluctuations of iodine number of butter fat due to type of oil consumed in the ration, and the tendency on the part of the cow to produce butter fat of an intermediate iodine number rather than to follow the extremes of the oils found in the ration.

SUMMARY

1. The feeding of 1 pound per day of cocoanut oil in the daily ration of a dairy cow decreased slightly the iodine number of the resulting butter fat and reduced slightly the intensity of the oxidized flavor developed by copper.

2. The feeding of 1 pound per day of either expeller, crude, or refined soybean oil in the daily ration of a dairy cow increased greatly the iodine number of the resulting butter fat and increased the susceptibility of the milk to metal-induced oxidized flavor.

3. The difference in the lecithin content of the different types of soybean oils produced no noticeable change on the development of oxidized flavor.

4. The feeding of 1 pound per day of hydrogenated soybean oil in the daily ration of the dairy cow increased slightly the iodine number of the

resulting butter fat. This is believed to be due to the desaturation of this fat by the cow.

5. In rations low in fat the change in iodine number of the butter fat does not appear to be correlated with the intensity of oxidized flavor developed. Apparently other factors are of more importance.

6. In these experiments the range in iodine number of butter fat has been from 23 as an average for the cocoanut oil supplement to 48 for refined and expeller soybean oil.

7. Under the conditions of these experiments, approximately three weeks were required before the iodine number of the butter fat had reached the period of maximum change.

ACKNOWLEDGMENT

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Likewise, the authors wish to express their appreciation to Durkee's Famous Foods Inc. of Chicago, Illinois for their cooperation and interest in helping us to obtain the oils used in these feeding trials.

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THE FREEZING AND THAWING OF MILK HOMOGENIZED AT VARIOUS PRESSURES*

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Although many observations and studies have been made on the effects of partial freezing on the distribution of fat and solids-not-fat of milk, few such investigations have been made on the freezing of homogenized milk.

Very soon after Vieth (24) in 1886 reported noting different qualities between frozen and unfrozen portions of milk and that the fluid part of partially frozen milk was richer in fat than the frozen part, Henzold (12) conducted several experiments on partial freezing of milk, showing that the fat content of the milk-ice was dependent in large part upon the creaming of the milk. If creaming occurred prior to freezing the milk ice was higher in fat than the fluid part and vice versa. Other workers, Richmond (19), Farrington (9), Bischoff (5), Mai (14), Utz (23), Winter (25), and Koenig (13) presented further evidence showing that the relative richness of the frozen and unfrozen portions of milk was dependent upon the extent of freezing and creaming. Later, Baldwin and Combs (1) showed that the freezing of the cream resulting from the fat rising before freezing began apparently accounted for the greater percentage of fat in the frozen portion. Baldwin and Doan (3) found that when the creaming of milk was destroyed by heating or by homogenization the fat concentration of the unfrozen portion increased as freezing progressed while that of the frozen portion was decreased at first but finally approached the fat percentage of the original milk as freezing approached 100 per cent.

When the milk was frozen solid the percentage distribution of constituents was found by Bordas and Raczkowski (6), Besana (4) and Fascetti (10) to vary widely depending upon the portions analyzed and the conditions of freezing. Doan and Baldwin (8) observed that if the fat content exceeded 25 per cent the product froze homogeneously when frozen unagitated, and that homogenization caused homogeneous freezing at a lower fat content.

Not only has the composition of milk been found to be affected by the freezing, but by the thawing as well. Pade (16) and Winter (25) noted a great variation in the composition of various portions of fractionally thawed frozen milk, that first obtained on thawing being quite rich in total solids.

Freezing of milk has often been considered as affecting the creaming of milk. Reid (18) observed that freezing greatly intensified the clumping of the fat globules. However, he found that the depth of the cream layer might be increased or decreased according to the conditions of freezing.

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Baldwin and Combs (2) concluded that the manner of thawing played the major role when decreases in the efficiency of creaming of partially frozen and thawed milk occurred.

A flaky appearance is commonly observed in thawed frozen unhomogenized milk. However, precipitation of solids of milk as a result of freezing has not been so generally noted. While Reid (17) observed that the milk serum after freezing and thawing was bluish and had a watery appearance he made no mention of the presence of a "ring of sediment or precipitate of a gelatinous-like character" as observed and analyzed by Munkwitz and coworkers (15). The Connecticut Station (7) reported that the precipitation of casein was not influenced by homogenization when the milk was held at – 14° F., but when stored at + 10° F. a pressure of 4000 pounds per square inch caused a precipitation of casein approximately twice as rapid as that homogenized at 2000 pounds, which had a slight effect when held under similar conditions.

Gooren (11) concluded from data of two trials that homogenization of milk slightly lowered its freezing point.

Inasmuch as homogenized milk sales are increasing and that few studies on freezing and thawing of milk involved the homogenized product a study of some of their effects on certain properties of homogenized milk seemed desirable.

EXPERIMENTAL

Mixed milk, averaging 3.8 per cent fat, pasteurized in a 200-gallon vat at 143° F. and homogenized at pasteurization temperature, using a 200-gallon per-hour viscolizer, was used throughout the study. The fat content of the various portions was determined by the Babcock method, the total solids by the Mojonnier method, and the solids-not-fat calculated from these two values. The titratable acidity was determined according to the Mann's acid test. Freezing, either partial or solid, was brought about at 0° F. and thawing, either by exposure to air at room temperature or to a water bath at 90–100° F. The samples were set for creaming in a room at 40° F. The various layers of milk in the creaming cylinders were obtained by a water suction pump using a trap within the suction line. Samples of drainage from thawing milk were secured by exposing to room temperature the stripped quart "Sealrights," placed on a triangle over a funnel.

RESULTS

Rate of freezing. Mixed milk homogenized at 0, 500, 1500, 2500 and 3500 pounds pressure and bottled was tempered at 40° F. for 24 hours and then exposed to 0° F. for 3 hours. At the expiration of this period a one-half inch hole was drilled in the frozen plug, through which the unfrozen portion was poured. The drillings were carefully saved and returned to the frozen portion. The percentage frozen was calculated from the weights of

the unfrozen and of the original milk. The average percentages of five series frozen has previously been reported (22) but is shown graphically in figure 1 as a background for the analytical data being presented in this paper. A slightly higher percentage of the milk homogenized at 2500 and

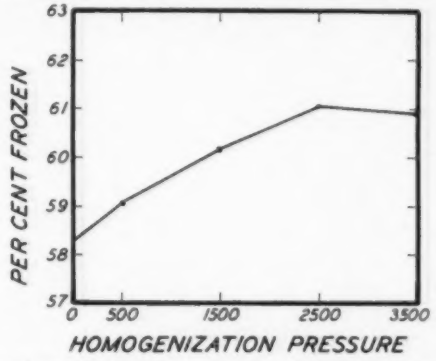

FIG. 1. Per cent of milk frozen at the end of three hours exposure to 0° F. when homogenized at various pressures.

3500 pounds froze during the three-hour exposure than that homogenized at 500 or 1500 pounds or that unhomogenized, the latter showing the least freezing. Despite evidence (11) that homogenization slightly lowers the freezing point of milk, these slight increases in the rates of freezing of homogenized over the unhomogenized milk must be associated chiefly with the different insulation values of the milk ice, the composition of which is influenced largely by the migration of the fat globule.

Analysis of solid and liquid portions of partially frozen milk. The series of milk homogenized at various pressures, previously discussed under rate of freezing, were tested for fat and total solids. The data obtained are illustrated in figure 2. The frozen portion of the unhomogenized milk had a higher fat content than the liquid portion. However, the reverse was true when the milk was homogenized. Despite the higher fat content in the frozen portion of the unhomogenized milk, the total solid content was lower than in the unfrozen portion. The lower total solid content in the frozen portion was noted also in the homogenized samples. However, the difference in the total solid content between the frozen and unfrozen portions of the unhomogenized milk was markedly less than that noted in the homogenized samples. In these trials in which the milk was frozen approximately 60 per cent, the unfrozen portion contained approximately 2.50 to 2.75 per cent more solids-not-fat than did the frozen portion, regardless of homogenization.

Five separate lots of milk heated to inhibit creaming exhibited the same trend in distribution of fat and solids as did the homogenized milk upon

similar partial freezing. These data confirm results of other investigations showing that the inhibition of creaming and not the decrease in the size of the fat globule was largely responsible for the lower fat content in the frozen portion than in the unfrozen portions of partially frozen homogenized milk.

The difference in the fat content of the frozen and unfrozen portions of the high-heat-treated milk was remarkably close to that noted when the milk was homogenized at low pressure on which no creaming was observed.

It should be pointed out again, however, that efficiency of the homogenization, beyond the pressure necessary to inhibit creaming, seemed to exert a slight influence on the rate of freezing, and, in this connection, analyses show a slightly greater difference between the fat content of the frozen and

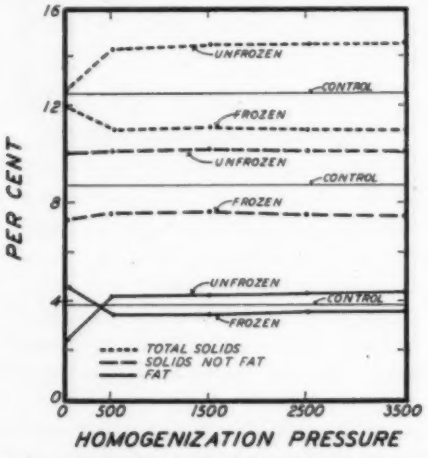

FIG. 2. Per cent fat, solids-not-fat and total solids in the frozen and in the unfrozen portions of bottled milk after three hours at 0° F. when homogenized at various pressures.

unfrozen portions as the pressure of homogenization was increased. However, this slight difference in composition attributed to pressure might be due to the slightly greater percentage frozen as a result of the pressure of homogenization.

Distribution of titratable acidity in partially frozen milk. The titratable acidity was found to be approximately 50 per cent higher in the liquid portion than in the solid portion of the partially frozen milk and showed no variation regardless of the pressure of homogenization. This distribution of titratable acidity seemed to follow quite closely the distribution of the solids-not-fat in the frozen and in the unfrozen portions.

The homogeneity of milk homogenized, frozen, and thawed under different conditions. Five series of mixed milk were pasteurized, divided into five lots and homogenized at 0, 500, 1500, 2500, and 3500 pounds respectively. Three 100-ml. cylinders of each lot were set at 40° F. for creaming.

After 24 hours two of the cylinders of milk were frozen solid at 0° F. for at least 12 hours. One cylinder was then set in a water bath at 90 to 100° F. while the other cylinder was exposed to the air at 70–75° F. When all traces of ice had disappeared the cylinders were again set at 40° F. for 24 hours for further creaming. The upper and the lower 50 ml. of milk were then drawn into separate half-pint milk bottles using a water suction pump.

The homogeneity of the milk was found to have varied greatly as a result of freezing and the rate of thawing and to a much lesser extent to the pressure of homogenization (figs. 3, 4, and 5).

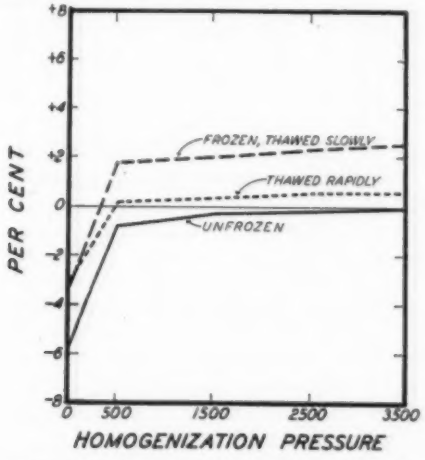

FIG. 3. The fat content of the lower half of creaming cylinders of milk with respect to that of the upper half when the milk was homogenized at various pressures, was frozen and was thawed under different conditions.

When homogenized milk remained unfrozen and was creamed for 48 hours there was a tendency for the fat to rise, the upper 50 ml. showing upon analysis a slightly higher fat content as well as a very slightly higher total solid and solids-not-fat content than the lower 50 ml. However, when the homogenized milk was frozen and thawed, slowly or rapidly, settling rather than creaming was encountered, as the lower 50-ml. portions always contained a markedly higher fat and total solids content. Especially was the settling out of the fat and total solids pronounced when the frozen milk was allowed to thaw slowly. The difference in analysis between the upper and lower layers seemed to be greater in case of the solids-not-fat than with the fat. Apparently the destabilized casein resulting from freezing and thawing although not showing flakiness in the homogenized milk, as commonly observed in frozen unhomogenized milk, swept down the fat as the heavier solids settled or else the fat globules, small as a result of homogeni-

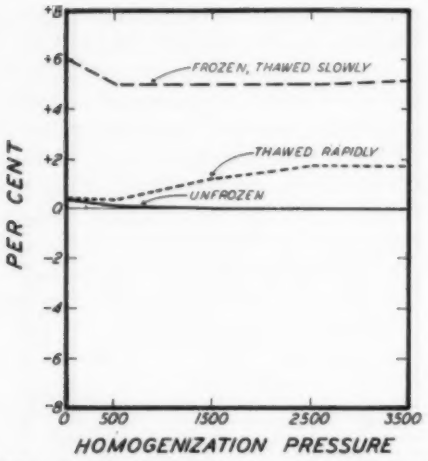

FIG. 4. The solids-not-fat content of the lower half of creaming cylinders of milk with respect to that of the upper half when the milk was homogenized at various pressures, was frozen and was thawed under different conditions.

zation, were weighted down through adsorbed destabilized casein. As previously reported (22), frozen homogenized milk when thawed under certain conditions presents a watery appearance in the surface layers. Analysis of the upper 15 per cent, middle 70 per cent, and lower 15 per cent of creaming cylinders of milk frozen and thawed as previously described furnish further

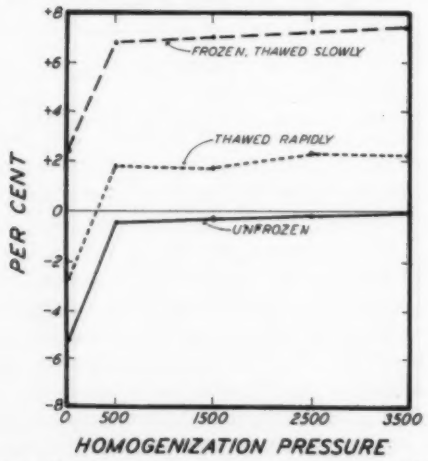

FIG. 5. The total solids content of the lower half of creaming cylinders of milk with respect to that of the upper half when the milk was homogenized at various pressures, was frozen and was thawed under different conditions.

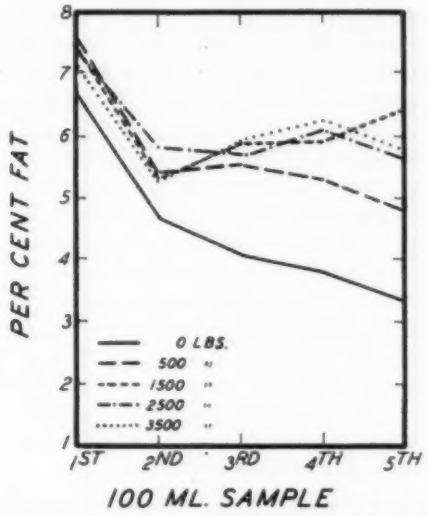

FIG. 6. The fat content of consecutive 100-ml. samples of drainage from quart "Sealrights" of frozen milk exposed to 70° F. when homogenized at various pressures.

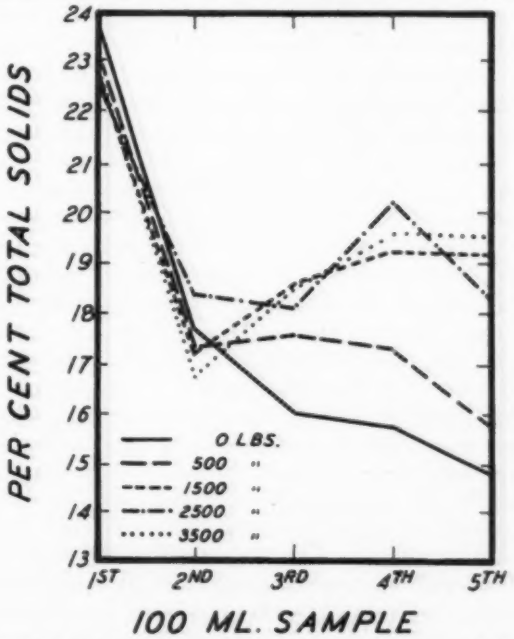

FIG. 7. The total solid content of consecutive 100-ml. samples of drainage from quart "Sealrights" of frozen milk exposed to 70° F. when homogenized at various pressures.

evidence of the settling of fat and total solids of homogenized milk under certain conditions and may serve to explain in part, the often spasmodic occurence of sediment in homogenized milk and its analysis (20, 21). When the milk was homogenized, for example, at 1500 pounds pressure, and was frozen and thawed slowly, the fat, solids-not-fat and total solids of the upper 15 per cent were found to be as low as 1.7, 3.09, 4.69 per cent, respectively, as contrasted to 7.7, 16.90, and 26.60 per cent, respectively, in the lower 15 per cent of the same samples. The titratable acidity in the upper and lower portions of the above samples was 0.04 and 0.35 per cent, respectively.

When the milk was heated sufficiently high to inhibit creaming and frozen and thawed the same as the homogenized milk, the fat tended to rise, forming a cream layer rather than settling as was the case in the homogenized milk.

The upper and lower halves of 100-ml. creaming cylinders of skim milk were studied also. Homogenization seemed to have little influence on the composition of the upper and lower layers but the freezing and rate of thawing had a marked effect as was noted in the whole milk.

The titratable acidity of upper and lower halves of creaming cylinders of milk frozen and thawed under different conditions. The per cents titratable acidity of the upper and lower portions of 100-ml. creaming cylinders of unfrozen milk were found to be practically identical regardless of the pressure of homogenization. However, when the milk was frozen and thawed the per cent acidity was always markedly higher in the lower layers than in the upper layers, the slower the thawing apparently the greater the difference in titratable acidity between the respective portions. Little consistent influence resulting from the pressure of homogenization was noted.

Composition of drainage from frozen milk upon thawing. Quart "Sealright" containers of milk homogenized at 0, 500, 1500, 2500 and 3500 pounds pressure were frozen solid at 0° F. for 48 hours, were stripped of the paper container, and were exposed at room temperature for complete melting. The frozen cylinders of milk were supported on a triangle above a large funnel conducting the drip into a 100-ml. cylinder. Each of the first five 100-ml. portions from each sample was caught separately, and analyzed for fat, total solids and titratable acidity. The data obtained are shown in figures 6 and 7. The data show that the fat drainage was somewhat slower in the unhomogenized than in the homogenized milk, the successive samples of drainage testing less in fat than the corresponding samples from the homogenized milk. Furthermore, the remaining portion after drainage of 500 ml. was higher in fat in the unhomogenized, being 1.90 per cent, than in the homogenized samples, which at 3500 pounds pressure was 0.80 per cent. Pressure of homogenization, except possibly 3500 pounds, in which sample less fat remained after removal of 500 ml. of drainage, seemed to have little consistent influence on the rate of fat drainage.

The drainage of total solids was found to be slightly faster in the first 100-ml. samples of milk processed at 0 and 500 pounds pressure than at 1500, 2500 or 3500 pounds pressure (fig. 7). However, this faster drainage of total solids in the unhomogenized milk was of short duration for in the third, fourth and fifth 100-ml. samples the total solid content became markedly less than in the respective samples of homogenized milk. Despite the higher total solids content of the first sample of drainage of unhomogenized milk, the remainder of the quart, after collecting five 100-ml. samples, contained more total solids than did those from the corresponding samples of homogenized milk.

The distribution of solids-not-fat and titratable acidity was quite similar to that of the fat and total solids. Similar studies were made on two series of skim milk. The data obtained on the respective samples were comparable to those found in the study of whole milk, namely, a slightly faster drainage of the total solids as a result of homogenization.

SUMMARY

The analyses of various portions of milk homogenized at different pressures and frozen partially or wholly have been made.

A slightly greater percentage of homogenized than unhomogenized milk froze in a given period at 0° F.

When creaming was inhibited by heating or by homogenization the unfrozen portion was relatively richer in fat and solids-not-fat than the frozen portion. When creaming occurred, as in the unhomogenized milk, the frozen portion was higher in fat but lower in solids-not-fat than the unfrozen portion.

The titratable acidity of the unfrozen portion was higher than the frozen portion, regardless of creaming. No evidence of creaming was noted in frozen homogenized milk but rather a pronounced settling of the fat which was influenced by the rate of thawing.

Frozen homogenized milk upon thawing exhibited no flakiness which was commonly observed when unhomogenized milk was frozen and thawed, but did exhibit a watery appearance at the surface layers which was more pronounced when the frozen milk was thawed slowly.

Marked settling of the fat and solids-not-fat of milk was noted when homogenized milk was frozen and then thawed. The rate of thawing had a pronounced influence upon the extent of settling of the fat and solids-not-fat; the lower 15 per cent of creaming cylinders of slowly thawed frozen homogenized milk contained as high as 7.7 per cent fat and 24.60 per cent total solids as contrasted to 2.0 and 5.50 per cent, respectively, of the upper 15 per cent layer. The titratable acidity of the upper and lower 15 per cent portions ranged from 0.04 to 0.35 per cent. Similar trends were observed upon freezing and thawing of skimmed milk. When milk was heated to

inhibit creaming was frozen and thawed, the fat tended to rise to form a cream layer, a contrast to the movement of fat in the thawed frozen homogenized milk.

The drainage of solids from homogenized milk was slightly faster after the first 100 ml. than that of the unhomogenized milk.

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SOME FACTORS AFFECTING THE BODY OF MARKET CREAM*

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The body of market cream refers to its appearance and is the commercial terminology employed to designate resistance to flow or deformation. This somewhat intangible property is a visual indication of quality to many consumers. Cream that flows slowly is regarded as having a high fat content and considered suitable for most purposes if the other inherent quality factors are present.

Dealers frequently encounter situations when their product shows a thin consistency and is frequently criticized as being deficient in fat, even though it meets the class requirements. Conversely, consumers sometimes complain of cream being so viscous that it will not readily pour from the bottle. Because of this consumer reaction that may not always be justified, the body of market cream has assumed commercial prominence and the dealer is continually seeking methods of processing that will aid in producing cream of uniform and acceptable body.

The literature on this subject was read by the authors. Detailed citations are omitted. Sommer (4) has contributed an excellent review of the fundamental factors involved in the viscosity of cream.

PROCEDURE

An approach to this problem was made through a study of creams subjected to various treatments and involving seasonal factors. The cream was obtained from mixed Ayrshire, Guernsey, Holstein and Jersey milk at the University Farm. The milk received at 40° F. was warmed to 80° F. within 15–20 minutes and then centrifugally separated. The cream was standardized with its own skimmilk.

When washed (3), the fresh cream was diluted with four volumes of water at 100°–110° F. and reseparated in a centrifugal machine, this process being repeated one to five times on different lots. The washed cream was standardized with water and the normal cream with its own skimmilk to the desired fat content. The creams were pasteurized for 20 minutes at 145° F. and cooled to 40° F., being gently agitated during heating and cooling, but not during holding.

Samples for viscosity determinations were taken in half pint bottles after the cream was cooled and held at 40° F. $\pm$ 2°. The measurements were made after 4 and 24 hours with the Borden Body Flow Meter designed

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by Nair and Mook (2) with an outlet of approximately 3.75 mm., each sample being poured into a second cold half-pint bottle, then into the cold test bottle and flow time measured in a laboratory temperature of 70–75° F. The increment in temperature due to handling and contact with warm air did not exceed 2° F. The viscosimeter was held at 40° F. prior to using. The average values for triplicate determinations of creams with a viscosity of less than 100 seconds rarely varied more than ± 1 second and for the more viscous creams did not usually vary more than ± 3 seconds from the mean.

The Borden Body Flow Meter has limitations not within the scope of this paper. Suffice it to state that comparisons between washed and normal cream are not on a comparable basis because of differences in specific gravity.

The experimental creams were observed for clustering of the fat globules with an oil immersion objective and a paraboloid condenser. They were diluted 25 times with their own skimmilk, a more satisfactory diluent than glycerine and water. All microscopic examinations were made at 40° F. ± 3°.

RESULTS

The viscosity of normal and of washed creams. Table 1 shows viscosity determinations on normal and washed creams, the latter being washed five

TABLE 1

The effect of washing on the viscosity of cream

Month	Trial No.	Fat	Age	Viscosity in seconds			
				Normal cream		Washed cream	
				Raw	Pasteurized	Raw	Pasteurized
1937		*per cent*	*hours*				
November	1	35	4	*	79.9	30.6	26.6
			24	*	132.0	34.8	28.0
November	2	35	4	*	79.2	33.3	23.1
			24	*	133.6	33.4	24.0
December	3	35	4	*	53.8	38.0	30.6
			24	*	94.1	43.0	38.0
December	4	35	4	201.6	72.5	37.5	31.9
			24	316.7	114.3	42.9	37.7
1938							
January	5	35	4	265.5	35.2	23.2	20.5
			24	341.2	40.4	24.5	21.5
February	6	35	4	*	44.8	45.0	35.7
			24	*	50.7	49.9	45.0
March	7	30	4	268.8	39.2	24.2	22.4
			24	*	44.4	26.4	23.4
April	8	30	4	128.4	40.2	24.9	22.9
			24	236.0	44.8	27.2	25.2
June	9	30	4	94.5	39.7	27.5	23.7
			24	144.5	42.2	29.4	26.2

* Too viscous to measure.

times. The data reveal in some cases that the raw cream was too viscous to flow. This was true in the trials conducted while the cows were on winter feed and such extremely high viscosity may be due to the physico-chemical state of the butterfat. It is a well known fact that fats of the lower melting points increase when the cows are pastured.

The viscosities of the pasteurized creams increased with age in the trials conducted during November and December, while during January to June the increases were small, in fact during this period the viscosity of the pasteurized creams did not change greatly with season. Washing cream greatly reduced the viscosity that was only slightly affected by pasteurization and age. This indicates that the plasma constituents are involved in viscosity changes with pasteurization and with age.

Effect of temperature treatment on the viscosity of pasteurized normal and washed cream. Table 2 shows viscosity values on temperature treated,

TABLE 2

Effect of temperature treatment on the viscosity of pasteurized normal and washed cream containing 30 per cent fat

Month	Trial No.	Age	Viscosity in seconds			
			Normal		Washed	
			Control	Heat treated	Control	Heat treated
1938		*hours*				
June 2	1	4	39.7	68.4	23.7	28.0
		24	42.4	108.2	26.2	36.8
June 9	2	4	37.0	72.1	24.1	28.9
		24	44.2	170.5	27.7	41.3
June 13	3	4	34.0	60.7	30.3	39.7
		24	40.0	152.6	35.0	68.3

normal and washed creams from milk produced while the cows were on pasture during June. The pasteurized creams were aged for 12 hours at 40° F. and subjected to the method of Hening and Dahlberg (1) for increasing viscosity. It is evident that the temperature treatment increased the viscosity; however, the increases for washed cream are not great. Results of the eight winter trials conducted during November to April are not shown because most of the temperature treated creams would not flow through the viscosimeter. These creams resembled a gel, and on standing at 40° F. in test tubes showed syneresis. This condition existed until the cows were pastured when the reaction to temperature treatment became less intense so that viscosity could be measured.

Effect of a modified temperature treatment. These experiments were conducted during the late fall and winter when the reaction to heat treatment was intense. The creams were pasteurized and quickly cooled to 82° F. Portions were held for varying lengths of time, followed by slow cooling in 20–30 minutes to 40° F. Control portions were cooled to 40° F.

Table 3 indicates that this processing reduced viscosity below that of the control. A slight tendency toward higher viscosity is indicated for the cream held at 82° F. for 20 minutes as compared to the other periods.

TABLE 3

Effect of a modified temperature treatment on the viscosity of 30 per cent cream

Month	Trial No.	Age	Viscosity in seconds				
			Pasteurized at 145° F. for 20 minutes				
			Control	Cooled to 82° F. and held for			
				10 min.	20 min.	30 min.	40 min.
1937		*hours*					
November	1	4	79.2	67.7	68.6	69.2	63.2
		24	133.8	85.2	89.0	87.4	73.9
November	2	4	65.8	58.7	59.9	60.2	59.6
		24	118.8	75.1	83.1	80.1	75.4
1938							
January	3	4	78.2	70.2	73.2	72.9	72.2
		24	126.5	82.4	84.4	83.0	80.2

However, the differences are of little significance since they were apparent only when measured by the viscosimeter. The controls showed higher viscosities in all cases. All the creams, except the controls, contained some free fat indicating destabilization of the emulsion.

Effect of repeated pasteurization and temperature treatment. These trials were made during the winter when the reaction to temperature treatment was intense. Normal cream and a portion of the same cream washed five times, pasteurized and promptly cooled to 40° F. was used for each trial. After aging for three hours, the creams were temperature treated, cooled and held at 40° F. After 24 hours they would not flow through the viscosimeter. They were again pasteurized and heat-treated, followed by another processing. In all, these creams were pasteurized and temperature treated three times. The results set forth in table 4 show that the first treatment increased the viscosity which was subsequently lowered by pasteurization. A second treatment reacted and the viscosity was increased only to be again lowered by a third pasteurization. This indicates that the substance or substances responding to heat treatment are not affected greatly by pasteurization.

Seasonal variation in the viscosity of pasteurized and of temperature treated cream. These trials were conducted during April 21 to July 19 and included winter and summer feeding. The cows were pastured on May 9. The evening milk was held over night at 40° F. and separated the following morning at 80° F. The cream for each trial was standardized, pasteurized, cooled rapidly to 40° F. with iced water and samples taken for viscosity determinations. A portion of the same cream was held at 40° F. for approximately 12 hours and was temperature treated.

TABLE 4

The effect of repeated pasteurization and temperature treatment on the viscosity of cream containing 30 per cent fat

Treatment	Age	Viscosity in seconds					
		Normal			Washed		
		Trial number					
		1	2	3	1	2	3
	hours						
First pasteurization	24	72.2	79.9	70.3	23.1	26.3	29.2
Heat treated	24	*	*	*	*	*	*
Second pasteurization	48	75.4	76.8	68.7	22.4	25.6	27.4
Heat treated	48	*	*	*	*	*	*
Third pasteurization	72	70.2	72.0	66.8	21.2	24.2	26.6
Heat treated	72	*	*	*	*	*	*

* Too viscous to measure.

The results set forth in table 5 show but little variation in viscosity of the pasteurized cream after aging for 24 hours. This was unexpected as it had been experienced that most complaints of poor cream body were associated with the transition from winter to summer feed. On the other hand

TABLE 5

Seasonal variations in the viscosity of pasteurized and of temperature treated cream containing 30 per cent fat

Month	Trial No.	Viscosity in seconds			
		Pasteurized			
		Normal		Heat treated	
		4 hrs.	24 hrs.	4 hrs.	24 hrs.
1938					
April 21	1	43.1	50.2	*	*
25	2	36.0	43.1	*	*
29	3	42.6	49.8	*	*
May 3	4	45.7	60.8	*	*
5	5	41.5	46.1	*	*
9	6	41.1	45.8	*	*
12	7	40.9	46.3	206.4	*
16	8	41.3	43.7	239.9	*
19	9	39.8	43.6	157.3	311.0
23	10	40.2	44.1	97.2	161.2
26	11	49.1	57.0	88.4	161.9
30	12	43.3	46.9	86.4	158.1
June 2	13	35.2	43.1	95.5	140.1
9	14	42.5	47.1	91.1	142.3
16	15	43.0	47.6	90.8	157.0
23	16	39.9	49.4	93.8	177.5
30	17	47.2	54.6	91.0	174.9
July 7	18	42.7	50.6	*	*
12	19	40.3	49.4	*	*
19	20	42.4	49.2	*	*

* Too viscous to measure.

significant changes were evident in viscosity of the heat treated creams with season when the cows were pastured on May 9. This condition prevailed for about six weeks when the creams again increased in viscosity by heat treatment so that flow-time could not be measured. No consistent relationship was evident between fat globule clumping and viscosity. This experiment was repeated through the same period in 1939 with similar results.

The stability of cream body. The purpose of the following trials was to determine the resistance of the body of market cream to handling. Cream was transferred from one halfpint bottle to another and this constituted one transfer in table 6. Successive transfers were made in denominations of ten and the viscosity measured. The trials were performed in a refrigerator at 45° F. ± 3° F. with forced circulation of air. It required approximately 1½ hours to complete the tests on each sample of pasteurized or heated cream that was previously aged for 24 hours. The increase in temperature due to handling the apparatus and the cream was 4–5° F.

The trials with pasteurized cream were made during January while those with pasteurized temperature treated cream were conducted during June. The results in table 6 indicate that cream has a temporary structure

TABLE 6

The stability of cream body

No. of transfers	Viscosity in seconds					
	Pasteurized 35 per cent			Pasteurized heat treated 30 per cent		
	Trial number					
	1	2	3	1	2	3
1938						
1	162.0	130.8	152.0	249.8	270.2	135.2
10	158.2	127.4	139.4	178.0	168.4	115.0
20	154.8	120.2	126.8	141.0	148.6	104.8
30	142.2	116.6	120.0	116.4	138.4	97.4
40	131.0	109.0	114.0	95.2	120.0	90.2
50	124.0	102.4	107.8	82.8	114.0	84.6
60	119.2	98.0	101.0	75.0	108.2	76.2
70	112.0	93.4	98.2	71.4	104.4	70.0
80	104.0	90.2	94.8	66.2	100.0	68.4
90	99.2	87.8	90.0	62.0	94.0	66.2
100	95.4	83.0	85.6	58.2	89.8	62.8
110	88.6	79.8	81.4	56.2	81.4	54.8
120	85.2	77.0	79.2	54.2	75.6	53.8
130	82.4	76.2	78.8	53.8	70.2	52.4
140	83.2	76.4	78.4	54.0	68.4	52.6
150	82.0	76.2	78.6	54.0	68.6	52.4
160	82.4	76.2	78.4	53.8	68.4	52.4
170	82.2	76.2	78.4	53.8	68.4	52.4

that may be reduced to a constant value under standard conditions. The six samples of cream showed slight clumping with no difference in degree

of clumping of the fat globules at the beginning and at the end of each trial.

DISCUSSION

The removal of most of the plasma constituents greatly reduced the viscosity of washed as compared to normal cream. The viscosity of the former did not vary greatly during the seasons studied. The washed and normal creams responded decidedly to the temperature treatment during the winter while responses during the summer were relatively less. This may be attributed to the predominance of higher melting point fats in the winter with resultant alterations in some physico-chemical properties.

The fact that the washed cream responded to temperature treatment that had not, previously, been greatly affected by successive exposures to pasteurization, indicates some thermal stability for the materials that are activated to increase viscosity. Furthermore, a certain degree of solidification is necessary to obtain maximum effects. It is probable that this condition might exert a greater effect in washed cream because of the reduced viscosity by removal of plasma colloids, thus allowing fat globule clusters to rise more rapidly and pack more solidly.

The body of cream is a temporary structural condition that can be altered by treatment. The formation of this structure in bottled cream has some practical significance in view of the fact that aging at low temperatures increases the viscosity. It is questionable if this structure is the same throughout the entire contents of the bottle. Fat rises and the plasma separates on the bottom, therefore, the fat content is higher in the upper part of the bottle and consequently the cream in this region would have a higher viscosity. Thus, the consumer pouring from a bottle would see the more viscous cream first and form immediate impressions as to the body. This condition would be intensified the longer the cream is held in a bottle or in a larger container at low temperatures. It is inevitable that fat globules rise and strike the viscous surfaces of one another and adhere to form temporary structures that contribute to the apparent viscosity.

From a practical standpoint the viscosity of cream is important insofar as its adaptability to the various uses is affected. There is no proof that extremely viscous cream that pours with difficulty is any more suitable for most manufacturing and household purposes than less viscous cream of the same fat and solids-not-fat content. Granting that viscous cream is produced, the question of handling this product must be considered. The losses that inevitably occur through sticking to equipment and bottles and added refrigeration are of importance.

CONCLUSIONS

1. The washed and the normal creams responded to temperature treat-

ment during the winter, but the responses were less during the summer, especially during the period of transition from winter to summer feed.

2. The viscosity of pasteurized cream aged for 24 hours was not greatly influenced by the transition from winter to summer conditions.

3. The viscosity of cream aged 24 hours and that imparted by temperature treatment is due in part to the formation of a temporary structural condition.

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THE RELATIONSHIP BETWEEN TYPE AND PRODUCTION

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The distinguishing characteristics between various breeds of livestock are principally conformation and color. It is true that all breeds of farm animals possess other characteristics in varying degrees such as rapidity of growth, fattening ability, fecundity, disposition, and in the case of dairy cattle milk yield and butterfat percentage and gait in the case of horses. With dairy cattle, there are also additional characteristics or traits identified with certain breeds, such as size or body weight, rate of maturity, grazing ability, temperature response, persistency of production and color of product.

Without differences in conformation and color, it would be difficult to distinguish one breed of livestock from another of the same species, whether the species be swine, horses or dairy cattle. If our different breeds of livestock are to be maintained, it is essential that standards of type or conformation be continued. Such standards may be flexible, changing with market demands as demonstrated in the swine industry during the past few decades. The value of breed standards of conformation is universally recognized in livestock circles. Without such standards, there can be no such thing as the show ring. Obviously, most of our present standards, especially those related to dairy cattle have been handed down to us. Our ideas of type and beauty in a dairy cow are largely the result of what we have been taught from the cumulative experience of past breeders. Production is of paramount importance in the dairy industry and consequently any standard of type or conformation for a dairy breed must either be definitely associated with producing capacity or at least not inimical to it. Certainly, it must be readily possible to combine both desirable type and high production in the same animal; otherwise, our breed standards of type are wrong.

The Jersey Herd Classification program furnishes perhaps the best yardstick for the measurement of conformation expressed by the score card or scale of points adopted by the American Jersey Cattle Club. The classification program, established in June, 1932, has grown steadily in popularity. Three years ago, a preliminary study was made regarding type and production and the results published in the JOURNAL OF DAIRY SCIENCE. At that time, however, the number of animals available was limited, especially in the case of classified bulls with classified progeny. Since then, a much larger number of animals has been classified and the number is now sufficient to furnish dependable material for study in determining the degree

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of relationship between the producing ability of a cow and her conformation.

Cows and bulls are classified by judges approved by the American Jersey Cattle Club and the cattle are given one of six ratings depending upon their conformation in relation to the scale of points of the Jersey breed. For instance, a cow to be rated "Excellent" must be an animal which in the opinion of the official judge would score at least ninety or more on the official scale of points. A cow to be classified "Very Good" must be an animal which in the opinion of the judge would be entitled to a score of approximately 85 but less than 90 on the official scale of points. The next rating of "Good Plus" is given to animals scoring approximately 80 but less than 85 points. The rating of "Good" is bestowed upon animals which in the opinion of the inspector would be entitled to a score of approximately 75 but less than 80 points. Cows which in the opinion of the judges are entitled to a score of 70 to 75 points are rated "Fair." All animals scoring less than 70 points are classified "Poor."

In applying for Herd Classification, the owner must submit every registered cow he owns that has ever calved and all bulls fifteen months of age or older. No exceptions are permitted. However, it is permissible and the practice is common for breeders to cull their herds (often quite rigidly) before the classifications are made. This explains the decided scarcity of animals that have been classified as "Fair" or "Poor."

Many of the animals that have been classified have also completed official production records either in the Register of Merit or in the Herd Improvement Registry. The records of these cows have been tabulated and converted to a mature yearly equivalent basis, using the American Jersey Cattle Club conversion factors. Table 1 shows the records of all the cows that have been classified to March 31, 1940.

TABLE 1

Production records of all animals classified to March 31, 1940

Classification groups	Total No. of cows classified	Number of cows with R. of M. or H.I.R. records	Per cent of cows with records	Average mature production of each group
Excellent	405	335	82.72	649.59
Very Good	1654	1164	70.37	614.65
Good Plus	2993	1890	63.15	590.28
Good	1936	1058	54.65	553.03
Fair	287	139	48.43	550.29
Poor	15	1	6.67	557.00
Totals	7290	4587	62.92	591.45

The information in this table has been previously published based on a smaller number of records and attention has been called to the relationship between the ratings of the animals classified and the production rec-

ords. In examining this table, it should be observed that a much greater percentage of the higher rating animals have production records than the lower rating animals. This very fact makes an accurate analysis of the data difficult. Nevertheless, the correlation between the production records and the classification records was determined. In making these calculations, two methods were employed. In table 1, there were 139 cows rated "Fair" with production records. These were all used and then an equal number of cows classified "Good" with production records were selected by random sampling. Likewise, 139 cows rated "Good Plus," 139 rated "Very Good" and 139 rated "Excellent" having production records were selected at random. This gave a total of 695 classified cows with production records. In the first calculation, each cow rated "Excellent" was given an arbitrary classification score. It is required that all animals rated "Excellent" be scored in detail by the judge and the average score of the cows that have been rated "Excellent" is 91.5. Thus each cow rated "Excellent" was given this score of 91.5. Each cow classified "Very Good" was asigned a score of 87.5. Each cow classified "Good Plus" was given a score of 82.5, each cow rated "Good" was given a score of 77.5 and "Fair" cows were assigned a score of 72.5. The highest production record of each cow was determined and computed to a mature yearly equivalent basis. The production records were then compared with the classification scores and the correlation coefficient was found to be $+.254 \pm .024$.

Another comparison was made with different scores assigned to the various classification groups. For instance, each cow rated "Excellent" was assigned a score of 6, each cow classified "Very Good" was given a type score of 5, each cow classified "Good Plus" was given a score of 4. Then each cow classified "Good" was assigned an arbitrary score of 3 and each cow classified "Fair" was given a score of 2. There was only one cow classified "Poor"' with a production record and this cow was not used but if "Poor" animals had been used in the analysis, they would have been given a score of 1. Then the production records of the 695 cows were correlated with these arbitrary type scores and the correlation coefficient was found to be $+.262 \pm .024$. This correlation is slightly higher than that reported by Dr. Lush (1) comparing classification ratings on Holstein cows with their production records.

These correlation coefficients are low but they are subject to error for the same reason as the averages given in table 1, because an equal percentage of each classification group has not been tested officially for production. To try to correct this defect, another analysis was made. It was found that of all the herds that have been classified, there were 68 owned by breeders that had done Herd Improvement Registry testing for at least a year prior to the date of classification and then continued the herd on test for at least another year after the classification was made. It was felt that

using the ratings of cows classified in these herds, the percentage of animals with records in each group would be more nearly equal. Consequently, all of the cows classified in these 68 herds were used and it was found that 1980 had completed production records. The production records of this group of cows were determined and the results are shown in table 2.

TABLE 2

Production records of all cows classified in herds doing continuous H.I.R. testing

Classification groups	Total No. of cows classified	Number of cows with official production records	Per cent of cows with records	Average mature 365 day production of each group
Excellent	140	124	88.57	637.27
Very Good	532	445	83.65	590.11
Good Plus	1015	840	82.76	574.37
Good	631	495	78.45	546.19
Fair	106	76	71.70	528.09
Totals	2424	1980	81.68	573.03

Table 2 should be compared with table 1, and it will be noticed that there is a slightly greater spread in production between the classification groups. Next, the cows were ranked in order of production and the results are shown in table 3. In the right hand column of this table, the average classification score for each production group is shown using the assigned arbitrary classification scores as previously explained.

TABLE 3

Average type score of classified cows with production records classified in herds doing continuous H.I.R. testing

Production groups	Excellent	Very Good	Good Plus	Good	Fair	Totals	Average score
900 lbs. and over	4	6	13	1	0	24	85.04
800 to 899 lbs.	7	23	45	13	2	90	83.53
700 to 799 lbs.	31	73	101	57	8	270	83.53
600 to 699 lbs.	34	103	176	101	10	424	83.01
500 to 599 lbs.	28	117	228	125	23	521	82.47
400 to 499 lbs.	15	101	201	125	21	463	82.08
Under 400 lbs.	5	22	76	73	12	188	80.74
Totals	124	445	840	495	76	1980	82.55

There were 76 of the cows rated "Fair" with production records. An equal number was selected at random from each of the other classification groups, giving a total of 380 animals. The correlation was then determined between the production records of this group of 380 animals and their classification ratings, using the arbitrary classification scores of 91.5, 87.5, etc. The correlation coefficient was found to be $+.307 \pm .024$. This correlation is slightly higher than the previous correlations but it is still not high enough to be very significant in indicating much relationship between type

and production. However, even with this group of cows, it was found that a slightly higher percentage of the animals rated "Excellent" have production records than the animals in the lower classification groups. This was probably caused by culling the herds, after the classifications were made. In other words, cows rated "Fair" and "Good" were often disposed of shortly after they were classified and the records were not completed. If an equal percentage of each classification group had been tested, the correlation coefficient would undoubtedly be higher.

The possibility of any ten animals picked at random in any classification group excelling any ten others selected at random from a different classification group was of interest and such selections were made six times. In making these selections, ten animals were picked at random from each classification group and compared with ten animals picked at random from each of the other classification groups. The results are shown in table 4, and indicate that selecting ten cows from any classification group will not positively insure higher producing animals than if ten cows were selected from a lower classification group.

TABLE 4

Chart showing average yield of 10 records selected at random from each classification group

Classification	Group 1 Aver. of 10 records	Group 2 Aver. of 10 records	Group 3 Aver. of 10 records	Group 4 Aver. of 10 records	Group 5 Aver. of 10 records	Group 6 Aver. of 10 records
Excellent	625	614	611	651	714	660
Very Good	628	621	620	564	574	576
Good Plus	572	627	569	665	563	588
Good	504	573	533	570	534	528
Fair	503	524	558	516	533	463

It has been suggested that the range in production within each classification group exceeds the differences between the various groups and that therefore the relationship between classification ratings and production is not significant. To determine the range in production of tested animals in each classification group, the following frequency table 5, was prepared.

TABLE 5

Frequency table showing distribution of records made by cows classified in various classification groups

Production divisions	Excellent	Very Good	Good Plus	Good	Fair
	per cent	*per cent*	*per cent*	*per cent*	*per cent*
800 lbs. and over	8.87	6.29	7.02	3.03	2.63
700 to 799 lbs.	25.00	16.40	11.91	11.52	10.53
600 to 699 lbs.	27.42	23.37	20.83	20.20	13.16
500 to 599 lbs.	22.58	26.29	27.14	25.66	30.26
400 to 499 lbs.	12.10	22.25	23.81	25.25	27.63
Under 400 lbs.	4.03	5.39	9.29	14.34	15.79

Examination of this table does illustrate that there is a wide range in the producing ability of cows in each classification group and from the data in this table and the data in table 6, it is apparent that there is just as much variation in the production of cows classified "Excellent" as there is with cows in the other classification groups. The variation in production within each classification group is so marked, that a classification rating alone is of little value in estimating the producing ability of an individual cow.

TABLE 6

Classification groups	No. of cows classified with records	Production mean	Mean deviation of records	Standard deviation
Excellent	124	637.27	108.58	137.49
Very Good	445	590.11	100.45	139.68
Good Plus	840	574.37	118.15	150.27
Good	495	546.19	117.86	145.43
Fair	76	528.09	108.80	135.77

In comparing the "Excellent" animals with the cows classified as "Very Good" and doing this at random for the entire groups, it was found that in sixty-two per cent of the times, the "Excellent" cows had higher records than the "Very Good" cows. On the same basis, the chances are 53 out of 100 that a "Very Good" cow will have a higher record than a "Good Plus" cow. The chances are 56 out of 100 that a "Good Plus" cow will excel a "Good" cow and the possibility of a "Good" cow exceeding a "Fair" cow in production is 57 times out of 100 chances. The odds, on an "Excellent" cow having a higher record than a cow classified as "Fair" was found to be 73 to 27, or 73 times out of 100, the "Excellent" cow will exceed the "Fair" cow in production. It is apparent that a single animal cannot be selected from any one classification group with reasonable assurance that the animal selected from this group will be better or worse in production than an individual animal selected from any other classification group.

There are also a number of classified bulls with tested and classified daughters. The number is not large but the data are included since the inheritance of type and production is of such vital importance. There are 124 classified bulls, each having ten or more officially classified daughters. Twenty-one of these bulls have been rated "Excellent." The average classification score of their daughters is 84.51 per cent. There are 56 of this group of bulls rated "Very Good" and the average classification score of their daughters is 83.46 per cent. Forty-one of this group of bulls have been rated "Good Plus" and the average classification score of their daughters is 82.20 per cent. The remaining six bulls all classified "Good" have an average score on their daughters of 80.12 per cent. The correlation between the ratings of the 124 bulls and the average score of their daughters

was found to be $+.39 \pm .05$. This correlataion is significant in indicating some relationship between the conformation of a bull and the conformation ratings of his progeny. However, in this connection, it must be recalled that in most instances the good type bulls were bred to good type cows, whereas the poorer type bulls were probably used on cows of poorer conformation.

Next, 504 classified cows having classified dams were selected at random. The conformation ratings on the dams were compared with the conformation ratings on the daughters. The results are given in table 7.

TABLE 7

Frequency table—showing ratings on classified dams and classified daughters

Conformation ratings on dams	Percentage of daughters in each classification group					Average score of classified daughters
	Excellent	Very Good	Good Plus	Good	Fair	
68 Excellent dams	26.5	38.2	27.9	5.9	1.5	86.35
185 Very Good dams	7.6	37.3	38.4	15.1	1.6	84.13
162 Good Plus dams	3.7	21.0	46.9	25.9	2.5	82.34
81 Good dams	3.7	16.1	35.8	38.3	6.2	81.10
8 Fair dams	0	0	37.5	62.5	0	79.38

The average score of the 504 classified dams was 84.59, whereas the average score on the classified daughters was 83.29. The actual correlation coefficient between the ratings on the dams and the ratings on the daughters was calculated and was found to be $+.360 \pm .026$. This correlation coefficient is just slightly lower than the correlation between the conformation of the bulls and the bulls' daughters. It is significant in indicating a fair relationship between the conformation of a cow and the conformation of her daughters.

There are 128 classified bulls that have qualified as "A.J.C.C. Tested Sires," each having ten or more officially tested daughters. Twenty-one of these have been rated "Excellent" and their daughters have an average production of 620 pounds of fat. Fifty-five of this group of bulls have been classified "Very Good" and their daughters average 604 pounds of fat. There are forty-one of the "Tested Sires" that have been classified "Good Plus" and the records of their daughters average 611 pounds of butterfat. Then, there are ten "Tested Sires" classified "Good" whose daughters average 629 pounds of fat. The entire group of 128 classified "Tested Sires" have tested daughters averaging 610.78 pounds of fat. The correlation between the classification ratings on this group of 128 bulls and the records of their daughters was found to be $-.18 \pm .06$. There appears to be no relationship at all between the classification rating of a bull and the production of his progeny.

SUMMARY

From a practical breeding standpoint several conclusions may be drawn from the foregoing data, even though the correlations reported are not pronounced. It can be stated that there is some relationship between the conformation of a cow and her producing ability. It is equally obvious, however, that a high conformation score is not a reliable guarantee of superior producing capacity.

In breeding for conformation, there appears to be about the same correlation between the conformation of a cow and the conformation of her daughters as there has previously been found to exist between the producing ability of a cow and the producing ability of her daughters. In both instances, the correlations are significant but are hardly high enough to definitely insure the type of progeny which may be desired from dams of a certain conformation. It does appear that there is no relationship between the conformation of a bull and the producing ability of his daughters.

It can be concluded that type as determined by the score card and producing ability are not incompatible and that they can readily be combined in the same animal, yet to secure our ideals of type and production, breeders must continue to pay close attention to both of these essentials in their breeding programs.

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THERMODURIC BACTERIA IN PASTEURIZED MILK. II. STUDIES ON THE BACTERIA SURVIVING PASTEURIZATION, WITH SPECIAL REFERENCE TO HIGH-TEMPERATURE, SHORT-TIME PASTEURIZATION

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The recent interest in thermoduric bacteria in milk has been stimulated especially by the development of modern methods for high-temperature short-time pasteurization; the adoption of tryptone glucose extract milk agar as the standard medium for plate counts; agitation for the substitution of 32° C. (89.6° F.) instead of 37° C. (98.6° F.) for incubation of plate counts; and more stringent bacterial standards by certain Departments of Health. The first three tend to give higher counts with many milk supplies, which makes it difficult for the industry to meet the desires of the Health Departments for lower counts. Breed (1) has pointed out the desirability of concentrating efforts "on the extension of pasteurization as a blanket means of protection against milk-borne diseases and upon the eradication of diseases that may be transmitted to human beings from our milk-producing herds" before spending "an undue amount of energy and valuable time in getting some harmless types of bacteria out of our milk supplies. These bacteria are usually detected only because of the fact that they are difficult to kill during the pasteurization process." However, so long as pressure for very low bacteria counts is put on the industry by Health Departments, thermoduric bacteria present a serious problem, and their elimination from the milk supply must be undertaken.

A review of the literature on thermoduric bacteria in milk, which up to the present time has referred chiefly to those organisms surviving pasteurization by the low-temperature long-hold method, has recently appeared (2), and no attempt will be made to review it fully here.

A number of papers has been published (2, 3) showing that milk pasteurized by the high-temperature short-hold method usually has a higher bacteria count than does milk pasteurized by the low-temperature long-hold method. The question naturally arises as to what organisms are responsible for the difference in count. Eglinton and Yale (4) reported that yellow micrococci, found to originate in dirty farm utensils, were especially common on agar plates made from milk pasteurized by the high-temperature method, but there seem to have been no detailed quantitative studies of the

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differences in the flora of milk pasteurized by the two methods. Such a study was therefore undertaken.

EXPERIMENTAL

Fifteen lots of mixed milk from a large plant, with about 400 producers, were pasteurized by three methods, as follows:

1. In the laboratory in glass test-tubes at 143–144° F. (61.6°–62.2° C.) for 35 minutes, with about 5 minutes to heat and 5 minutes to cool.

2. In the laboratory in glass vials at 161° F. (71.5° C.) for 16 seconds. Five cubic centimeters of milk were placed in a 4 dram homeopathic vial, with the aluminum cap screwed down tight. The entire vial was completely immersed in a water bath maintained at 165° F. (75.9° C.) A thermometer dipped into the same amount of milk in a test-tube of the same diameter and same wall thickness as the vials. The milk reached 161° F. in about 2 minutes, when the rack holding the vials was removed from the water and held in the air for 16 seconds. The temperature rose to about 162° F. (72.2° C.) and then dropped to 160° F. (71.1° C.) during the 16 seconds, averaging very close to 161° F., after which the vials were dipped (but not immersed) into cold water. Expanding air in the vials prevented water from entering during the heating.

3. In a commercial plant, with a capacity of 22,000 pounds of milk per hour, at 161° F. for 16 seconds. In this apparatus, the temperature of the milk rose to 158° F. (70° C.) in 44 seconds, dropped to 143° F. (61.6° C.) in 4 seconds, finally reached 161° F. (71.5° C.) in 11 seconds, was maintained at 161° F. for 16 seconds, and was reduced to 40° F. (4.4° C.) in 35 seconds.

After cooling, plates were made from each of the three samples with tryptone glucose extract milk agar, and incubated 48 hours at 35°–37° C. Every colony from all three plates was inoculated into a tube of sterile litmus milk, incubated 48 or 72 hours at 35–37° C., and the reaction noted. Morphology of the cultures was determined microscopically. In all, 911 cultures from

TABLE 1

Litmus milk reactions of the bacterial flora of mixed plant milk pasteurized by three methods

Litmus milk reaction	Laboratory pasteurization at 143° F. for 35 minutes		Laboratory pasteurization at 161° F. for 16 seconds		Plant pasteurization at 161° F. for 16 seconds	
	Number	Per cent	Number	Per cent	Number	Per cent
Produce acid	182	93.3	173	65.8	205	45.3
Produce alkali	8	4.1	81	30.8	231	51.0
No change	4	2.1	6	2.3	11	2.4
Peptonize	1	0.5	3	1.1	6	1.3
Total	195	100.0	263	100.0	453	100.0

the 15 lots of milk (45 plates) were examined. Tables 1 and 2 show summaries of the results.

The significant features of table 1 are the decrease in the percentage of acid producers and the increase in the percentage of alkali producers in going from low-temperature laboratory pasteurization to high-temperature laboratory pasteurization to high-temperature commercial pasteurization. Table 2 shows an even sharper decrease in percentage of streptococci and increase in percentage of micrococci in going through the three methods of pasteurization.

TABLE 2

Morphological form of the bacterial flora of mixed plant milk pasteurized by three methods

Morphological form	Laboratory pasteurization at 143° F. for 35 minutes		Laboratory pasteurization at 161° F. for 16 seconds		Plant pasteurization at 161° F. for 16 seconds	
	Number	Per cent	Number	Per cent	Number	Per cent
Streptococci	134	68.7	78	29.7	80	17.7
Micrococci	46	23.6	156	59.3	346	76.4
Sarcinae	8	4.1	4	1.5	5	1.1
Rods	7	3.6	25	9.5	22	4.8
Total	195	100.0	263	100.0	453	100.0

In connection with table 1 it should be emphasized that the decrease in the *percentage* of acid producers in going from low-temperature laboratory to high-temperature laboratory to high-temperature plant pasteurization does not mean a decrease in *numbers* of these organisms surviving. The numbers of cultures of acid producers isolated from the milk pasteurized by the three methods were 182, 173 and 205, the differences being within what may be considered to be experimental error. However, the numbers of cultures of alkali producers isolated from the same samples were, respectively, 8, 81 and 231, a very significant increase.

The great increase in the numbers of alkali producers surviving high-temperature pasteurization, as compared with low-temperature pasteurization, might be considered by some as an undesirable feature of milk pasteurized by the high-temperature method. Milk containing these alkali producers might be expected not to sour normally, but might be more apt to develop undesirable flavors and odors as it gets old. The species of bacteria found are all undoubtedly entirely harmless except for this possibility of development of off-flavors if the milk were not properly cared for after delivery to the consumer. No evidence is at hand to indicate that such undesirable forms of spoilage actually do occur, and the distribution, over a period of 18 months, of large amounts of milk pasteurized in the commercial high-temperature short-time plant has not led to any particular complaint along this line.

From table 2 it appears that somewhat more streptococci occur in milk pasteurized at the low temperature than in that pasteurized at the high temperature. Examination of table 4, where numbers per cubic centimeter of the various types of organisms are given for each sample separately, reveals that samples 12 and 13 account for this. Data are not available to show why these two samples contained so many more than the average number of streptococci capable of surviving low-temperature pasteurization. It might be that these two samples contained streptococci able to survive low-temperature pasteurization better than high-temperature, or that growth of *Streptococcus thermophilus* occurred during the 35-minute holding, but neither explanation seems very probable.

Since the alkali-producing bacteria make up such a large percentage of the flora of the milk pasteurized in the commercial apparatus at 161° F. (71.5° C.) for 16 seconds in this particular plant, it is of interest to analyze further the data on the commercially-pasteurized milk. Table 3 shows monthly averages over a five-month period covering the counts of all organisms, of alkali-producing organisms, and of non-alkali-producing organisms. The total count increased gradually from April through August and it is obvious that this increase can be attributed quite largely to the alkali-producing organisms, except for the month of August.

TABLE 3

Numbers per cubic centimeter of various types of organisms surviving commercial high-temperature pasteurization

Month	Number of differential counts made	Monthly average of counts		
		Total organisms	Alkali producers	Non-alkali producers
April	1	14,000	None	14,000
May	2	20,000	5,000	15,000
June	7	31,000	16,000	15,000
July	4	34,000	24,000	10,000
August	1	45,000	14,000	31,000

Table 4 shows, for each of the 15 lots of milk, the numbers per cubic centimeter of various types of organisms surviving when the milk was pasteurized by the three methods. The increase in the number of alkali producers in going from laboratory low-temperature to laboratory high-temperature to plant high-temperature pasteurization accounts for most of the increase in total count, leaving the number of non-alkali-producing organisms nearly constant in the milk pasteurized by all three methods. However, examination of the two right-hand columns shows that changes in the flora other than an increase in the number of alkali-producing organisms occur when changes in the method of pasteurization are made. The number of streptococci (all of which were acid-producers) decreases, and the number of non-alkali-producers other than streptococci increases, when a change from low-

TABLE 4

Number per cubic centimeter of various types of organisms surviving in milk pasteurized by three methods

Pasteurization method	Sample number	Numbers of organisms				
		Total organisms of all kinds	Organisms producing alkali	Organisms not producing alkali		
				Total	Streptococci	Organisms other than streptococci
143° F. for 35 minutes in the laboratory	1	10,000	3,000	7,000	4,000	3,000
	2	10,000	0	10,000	2,000	8,000
	3	6,000	0	6,000	1,000	5,000
	4	11,000	1,000	10,000	7,000	3,000
	5	15,000	0	15,000	12,000	3,000
	6	8,000	0	8,000	7,000	1,000
	7	3,000	0	3,000	3,000	0
	8	6,000	1,000	5,000	3,000	2,000
	9	5,000	0	5,000	3,000	2,000
	10	1,000	0	1,000	1,000	0
	11	5,000	0	5,000	1,000	4,000
	12	40,000	0	40,000	39,000	1,000
	13	32,000	3,000	29,000	29,000	0
	14	21,000	0	21,000	13,000	8,000
	15	22,000	0	22,000	3,000	19,000
	Average	13,000	533	12,466	8,500	3,933
161° F. for 16 seconds in the laboratory	1	9,000	2,000	7,000	2,000	5,000
	2	9,000	0	9,000	2,000	7,000
	3	24,000	7,000	17,000	9,000	8,000
	4	13,000	2,000	11,000	5,000	6,000
	5	25,000	3,000	22,000	15,000	7,000
	6	20,000	7,000	13,000	5,000	8,000
	7	16,000	9,000	7,000	2,000	5,000
	8	37,000	22,000	15,000	12,000	3,000
	9	19,000	7,000	12,000	5,000	7,000
	10	8,000	0	8,000	6,000	2,000
	11	9,000	3,000	6,000	2,000	4,000
	12	12,000	8,000	4,000	1,000	3,000
	13	17,000	8,000	9,000	5,000	4,000
	14	10,000	2,000	8,000	2,000	6,000
	15	35,000	1,000	34,000	5,000	29,000
	Average	17,533	5,400	12,133	5,200	6,933
161° F. for 16 seconds in the plant	1	14,000	0	14,000	4,000	10,000
	2	20,000	4,000	16,000	1,000	15,000
	3	20,000	6,000	14,000	7,000	7,000
	4	23,000	6,000	17,000	7,000	10,000
	5	43,000	13,000	30,000	24,000	6,000
	6	26,000	12,000	14,000	7,000	7,000
	7	34,000	18,000	16,000	4,000	12,000
	8	45,000	33,000	12,000	4,000	8,000
	9	29,000	16,000	13,000	2,000	11,000
	10	16,000	13,000	3,000	2,000	1,000
	11	28,000	12,000	16,000	7,000	9,000
	12	27,000	23,000	4,000	0	4,000
	13	56,000	41,000	15,000	4,000	11,000
	14	27,000	20,000	7,000	0	7,000
	15	45,000	14,000	31,000	7,000	24,000
	Average	30,200	15,400	14,800	5,333	9,467

temperature to high-temperature pasteurization is made. The increase in the last-mentioned group consists largely of acid-producing micrococci. The unusually large numbers of streptococci surviving low-temperature pasteurization in samples 12 and 13 have already been discussed.

All of the cultures obtained from three of the lots of milk pasteurized in three ways (or from nine plates in all) were identified, using the classification of Sherman (5) for the streptococci and of Hucker (6) for the micrococci. Table 5 shows the results. Here again, we see the decrease in percentage of streptococci and the increase in percentage of micrococci observed in table 2 in going from low-temperature laboratory pasteurization to high-temperature laboratory pasteurization to high-temperature commercial pasteurization. The two species of streptococci (5) and six of the nine species of micrococci (7, 8, 9) encountered have previously been shown by other workers to be capable of surviving low-temperature long-time pasteurization. The three species of micrococci not previously known to be thermoduric (*M. flavus, M. freudenreichii* and *M. caseolyticus*) were found only in the milk pasteurized in the laboratory at 161° F. (71.5° C.) for 16 seconds, and the three combined made up only 9.6 per cent of the cultures identified from such milk.

TABLE 5

Species of bacteria surviving in three different lots of mixed plant milk pasteurized by three methods

Specific name	Laboratory pasteurization at 143° F. for 35 minutes		Laboratory pasteurization at 161° F. for 16 seconds		Plant pasteurization at 161° F. for 16 seconds	
	Number of cultures	Per cent of cultures	Number of cultures	Per cent of cultures	Number of cultures	Per cent of cultures
M. candidus	2	8.7	11	26.2	31	35.2
S. bovis	9	39.2	12	28.6	15	17.1
S. thermophilus	6	26.1	4	9.5	14	15.9
M. epidermidis	1	4.3	4	9.5	13	14.8
M. luteus	1	4.3	3	7.1	9	10.2
M. varians	3	13.1	3	7.1	3	3.4
M. conglomeratus	1	4.3	1	2.4	2	2.3
M. flavus	.....	.....	2	4.8	.....	.....
M. albus	.....	.....	.....	.....	1	1.1
M. freudenreichii	.....	.....	1	2.4	.....	.....
M. caseolyticus	.....	.....	1	2.4	.....	.....
Total	23	100.0	42	100.0	88	100.0
Micrococci	8	34.7	26	61.9	59	67.0
Streptococci	15	65.3	16	38.1	29	33.0

It seemed desirable to determine if the milk from individual farms would give a flora similar to that obtained from the mixed plant milk. Therefore, samples of milk from 49 farms which had at some previous time shown high

thermoduric counts were pasteurized in the laboratory at 161° F. (71.5° C.) for 16 seconds, plate counts were made and all of the 484 colonies from all of the plates were inoculated into sterile litmus milk and examined as in the case of the mixed plant milk. The data are summarized in tables 6 and 7. Results are very similar to those obtained in the examination of the mixed plant milk (tables 1 and 2), except that the percentages of alkali producers and of streptococci were somewhat lower. These particular samples were studied in August. Examination of the bottom line of table 3 will show that the single sample of commercially-pasteurized milk examined in August also contained a smaller percentage of alkali producers than usual, only 31.1 per cent as compared with an average of 53.2 per cent in the other 14 lots of commercially-pasteurized milk examined. This single lot of mixed plant milk examined in August contained only 1 alkali producer out of a total of 35 cultures examined (or 2.9 per cent) when pasteurized in the laboratory at 161° F. for 16 seconds. The causes of these fluctuations have not been determined.

TABLE 6

Litmus milk reaction of bacteria surviving in the milk of 49 producers pasteurized in the laboratory at 161° F. for 16 seconds

Litmus milk reaction	Number of cultures	Per cent of cultures
Produce acid	340	70.3
Produce alkali	85	17.6
Produce no change	38	7.8
Peptonize	21	4.3
Total	484	100.0

TABLE 7

Morphology of bacteria surviving in the milk of 49 producers pasteurized in the laboratory at 161° F. for 16 seconds

Morphological form	Number of cultures	Per cent of cultures
Micrococci	384	79.3
Streptococci	36	7.4
Sarcinae	39	8.1
Rods	25	5.2
Total	484	100.0

Thirty-eight of the 484 cultures were identified. The cultures chosen for identification were from the predominant group, based on litmus milk reaction and morphology, making up the bulk of the flora in the pasteurized milk from each farm where the thermoduric count was high. Names of these organisms are given in table 8. The species are the same as those found in the mixed plant milk pasteurized in the same way, except that *S. bovis* was not encountered in the farm samples.

The next step in tracing the source of the thermoduric bacteria in milk pasteurized at 161° F. for 16 seconds consisted of checking equipment on

TABLE 8

Names and approximate proportions of the typical organisms found in the milk of individual producers giving high counts after pasteurization in the laboratory at 161° F. for 16 seconds

Specific name	Number of cultures	Per cent of cultures
M. candidus	9	23.7
S. thermophilus	6	15.8
M. epidermidis	1	2.6
M. luteus	7	18.4
M. varians	2	5.3
M. flavus	1	2.6
M. conglomeratus	7	18.4
M. freudenreichii	3	7.9
M. caseolyticus	2	5.3
Total cultures	38	100.0
Micrococci	32	84.2
Streptococci	6	15.8

19 of the 49 farms referred to above. The worst milk cans that were found on the farms, from the standpoint of rust and cracked seams, were rinsed with two quarts of sterile milk. Two quarts of sterile milk were also used to rinse strainers and pails (combined) on 17 farms. In the case of the 11 milking machines examined, four quarts of sterile milk were drawn through the teat cups and tubes into the milking machine pails. Samples of the rinsings were pasteurized in the laboratory at 161° F. for 16 seconds, and plated at three dilutions, so as to get plates with few enough colonies for easy picking into litmus milk. The results of the examination of 520 cultures so isolated are shown in tables 9 and 10. These data differ somewhat from those on the mixed plant milk pasteurized at the same temperature in that there are fewer alkali producers and fewer streptococci. In this respect the cultures obtained from the milk of individual producers resembled those obtained from farm equipment more closely than either of these two groups of cultures resembled those obtained from mixed plant milk. In all three groups of cultures, micrococci predominated. The utensils also were examined in August.

TABLE 9

Litmus milk reaction of the bacteria isolated from utensils on 19 farms and capable of surviving pasteurization in the laboratory in milk at 161° F. for 16 seconds

Litmus milk reaction	Milk cans on 7 farms		Milking machines on 11 farms		Strainers and pails on 17 farms		Total for all utensils	
	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
Produce acid	40	58.8	232	95.10	178	85.6	450	86.5
Produce alkali	10	14.7	2	0.80	7	3.4	19	3.7
Produce no change	16	23.5	5	2.05	17	8.2	38	7.3
Peptonize	2	3.0	5	2.05	6	2.8	13	2.5
Total	68	100.0	244	100.0	208	100.0	520	100.0

TABLE 10

Morphology of the bacteria isolated from utensils on 19 farms and capable of surviving pasteurization in the laboratory in milk at 161° F. for 16 seconds

Morphology	Milk cans on 7 farms		Milking machines on 11 farms		Strainers and pails on 17 farms		Total for all utensils	
	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
Streptococci	5	7.4	8	3.2	13	6.3	26	5.0
Micrococci	37	54.4	171	70.1	156*	75.0	364	70.0
Sarcinae	0	0.0	58	23.8	23	11.0	81	15.6
Rods	26	38.2	7	2.9	16	7.7	49	9.4
Total	68	100.0	244	100.0	208	100.0	520	100.0

* Of the 156 micrococci isolated from strainers and pails, 60, or 28.8 per cent of the 208 cultures, grew in definite tetrads (not cubes). This was the largest group of these organisms found.

Seventeen of what appeared to be the most common cultures obtained from strainers and pails and from milking machines were identified, as shown in table 11. All of the 6 species found among these 17 cultures had previously been found in the mixed plant milk and in the milk from individual farms, pasteurized in the laboratory at 161° F. for 16 seconds. All but *M. freudenreichii* (of which 1 culture only was encountered) had been previously reported by other workers as being capable of surviving pasteurization by the low-temperature long-time method (7, 8, 9).

TABLE 11

Names and approximate proportions of the bacteria found in equipment on dairy farms and capable of surviving laboratory pasteurization at 161° F. for 16 seconds

Specific name	Strainers and pails		Milking machines		Total	
	Number of cultures	Per cent of cultures	Number of cultures	Per cent of cultures	Number of cultures	Per cent of cultures
M. varians	2	25.0	3	33.3	5	29.4
M. luteus	2	25.0	3	33.3	5	29.4
M. candidus	1	12.5	2	22.2	3	17.6
S. thermophilus	1	12.5	1	11.1	2	11.8
M. conglomeratus	1	12.5	...	.....	1	5.9
M. freudenreichii	1	12.5	...	.....	1	5.9
Total	8	100.0	9	99.9	17	100.0
Micrococci	7	87.5	8	88.8	15	88.2
Streptococci	1	12.5	1	11.1	2	11.8

SUMMARY AND CONCLUSIONS

The higher bacteria counts occurring in milk pasteurized by the high-temperature short-hold method as compared with the low-temperature long-hold method are largely due to the ability of certain species of micrococci to

survive the former method of pasteurization in greater numbers. The most common species of micrococci among those found in the milk pasteurized at high temperature are *M. candidus*, *M. epidermidis*, *M. luteus* and *M. varians*, although five other species were encountered less frequently. These micrococci make up the predominant thermoduric flora of dirty milking machines, strainers and pails on farms, and about half of the thermoduric organisms isolated from milk cans. However, milk cans at the plant where this work was done were not an important source of thermoduric bacteria.

The work of Harding and Wilson (10) and of Alice Breed (11) indicates that micrococci make up about 75 per cent of the flora of the normal cow's udder. They studied in all 226 cultures and found that six of the seven species encountered in commercially pasteurized milk in the work reported here made up about 60 per cent of the micrococci of the udder, or over 45 per cent of the total flora of normal udders. The only species encountered in this work not found in the udder by these previous workers was *M. caseolyticus*, and only 3 cultures of this organism were encountered among a total of 153 cultures of micrococci identified. The principal source of bacterial contamination of the rubber tubes of a milking machine is probably the milk itself. Moreover, many of these species of micrococci can survive inefficient hot-water sterilization just as they can survive pasteurization. Robertson (12) reports that many of them apparently also can survive sterilization by chlorine sterilizers and by salt brine. All this explains very well the source of the thermoduric micrococci in the milk. They originate in the udder and grow in improperly cleaned dairy farm utensils.

Workman has reported (13) that micrococci occur in the soil, in the stable air, and on the skin of cows. All of these sources doubtless contribute somewhat to the original contamination of dairy farm utensils and of the milk itself. However, it must be emphasized that dust, dirt from the skin of the cow, and the udder itself contribute relatively very small numbers of organisms to the milk (14, 15). Only when dairy farm utensils are improperly cleaned so as to offer a place where the micrococci can multiply does the problem of thermoduric bacteria become a serious one.

The data presented here were obtained at a single large milk plant, with about 400 producers. Whether similar results would be obtained with other milk supplies can only be determined by further investigation, now under way.

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THE USE OF NEMBUTAL ANESTHESIA IN MILK SECRETION STUDIES*

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Since the development of reliable methods for obtaining arterial and mammary venous blood samples for the study of milk secretion in normal intact animals, the avoidance of excitement during sampling has been shown to be one of the prime requisites for securing results of physiological value. Graham, Kay, and McIntosh (1) showed that valid results could be obtained with cows if the venous sampling was completed within two minutes and the arterial sampling within four minutes or less after first touching the animal. They reported that there was no detectable change in arterial blood if the above time limits were not exceeded. However, they stated that even if these precautions are observed, serious disturbance of the animal will decrease the value of the results. Blackwood and Stirling (2) detected no significant changes in the iron content of the blood in traversing the mammary gland. Graham *et al.* (3) reported changes in hemoglobin concentration averaging less than one per cent between arterial and venous samples of goat blood. On the other hand, Petersen and Boyd (4) and Shaw and Petersen (5) reported that large changes in blood volume, as indicated by differences in the hemoglobin level, occur frequently in arterio-venous samplings from cows, and they correlated these changes with the degree of excitation of the animal. Attempts to correct the analytical values for blood volume changes led to untenable results, and they recommended that only those samples showing little or no change in blood volume be used in studying milk secretion. Further difficulties in the study of certain phases of milk secretion in the normal intact goat are shown by the report (6) that the total nitrogen of both arterial and venous blood and plasma fluctuates sufficiently from moment to moment to mask, in some cases, the actual uptake of nitrogen by the mammary gland that would be involved in milk secretion.

In view of the variation in results encountered in sampling normal animals it was decided to test the feasibility of securing arterio-venous differences with the animal under the influence of a general anesthetic. Nembutal was chosen for this purpose because it had been shown by Hrubetz and Blackberg (7) to have no effect on the level of blood sugar during the period of anesthesia. Hafkesbring *et al.* (8) reported that dogs anesthetized

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with nembutal once a week for 6 to 8 weeks show no significant change in blood or urine composition.

In order to determine the effect of the anesthetic on the rate of milk secretion, two goats were nembutalized, following which they were milked out completely with the aid of one-half ml. of pituitrin given intravenously to eject the last of the milk. The anesthesia was maintained for 3½ and 4 hours, respectively, by periodic injections of small amounts of nembutal. The goats were then milked exactly as at the start of the period. The normal hourly milk production previous to the experiment was computed from the average daily yield of the 4 previous days. It was found (table 1) that the anesthesia had no effect on the rate of milk secretion, since the hourly milk yield in both cases was within one-half ml. of the normal. Suitable control values for the milk analysis were not obtained, but the constituents of the experimental milk samples were well within the range for normal goat milk.

TABLE 1

The effect of nembutal anesthesia on the yield and composition of milk

	Milk production	
	Goat No. 836	Goat No. 438
	ml.	*ml.*
Normal		
Milk per hour	27.45	39.0
Experimental		
Total yield	108.0	135.0
Milk per hour	27.0	38.5
Hours on experiment	4.0	3.5

Composition of milk produced under anesthesia

	Fat	Lactose	Total nitrogen	Calcium
	per cent	*gms. per 100 ml.*	*mgm. per cent*	*mgm. per cent*
Goat No. 836	6.9	4.73	523	151.5
Goat No. 438	4.4	5.12	452	148.8

In preparation for drawing blood samples the goats were given an intraperitoneal injection of 25 to 30 grains of nembutal for a mature animal weighing 70 to 90 pounds. After allowing 15 to 30 minutes for the anesthetic to take effect the samples were drawn by the method of Graham, Gomez and Turner (9) into flasks coated with equal amounts of sodium fluoride and potassium oxalate. Care was taken to assure free and unimpeded respiration of the animal during the entire procedure since any interference with respiration was found to have a disturbing effect on the oxygen and carbon dioxide levels of the blood. In order to prevent excess saliva from collecting in the respiratory passages and hampering respiration the animal was placed with its head at a lower level than the body, and its tongue drawn out of the side of its mouth to provide drainage.

TABLE 2

Arteriovenous differences of blood sugar of lactating goats under nembutal anesthesia

Exp. No.	Goat No.	Blood sugar			
		Arterial	Venous	Difference	Hemoglobin difference
		mgm. per cent	*mgm. per cent*	*mgm. per cent*	*per cent*
41	231	41.56	27.68	14.88	+2.00
46	231	39.44	27.93	11.52	0
47	231	41.36	25.52	15.84	−0.65
57	231	36.25	24.56	11.75	+0.98
59	231	43.75	32.75	11.00	−1.79
60	231	44.75	27.75	17.00	−0.49
71	231	39.75	27.00	12.75	−0.60
74	231	49.60	41.50	8.10	+0.96
62	842	40.25	32.00	8.25	+0.17
63	842	49.00	38.00	10.60	+1.80
65	842	42.00	33.25	8.75	+0.68
66	842	44.50	32.75	11.75	−1.25
69	842	53.50	40.00	13.50	+0.86
70	842	50.00	39.50	10.50	+1.44
72	842	53.25	41.50	11.75	−0.15
76	842	54.00	42.75	11.25	+0.40
77	842	58.00	47.75	10.25	+1.60
78	842	56.80	46.00	10.80	0
79	842	58.75	49.80	9.95	+1.11
80	842	56.80	48.00	8.80	+1.52
81	842	51.00	43.50	7.50	+2.57
82	842	51.75	43.50	8.25	−1.50
42	836	50.93	37.52	13.41	+1.25
84	836	49.20	33.75	15.45	−1.13

Blood sugar was determined by the Shaffer-Somogyi method (10) and total hemoglobin by the photoelectric method of Evelyn and Malloy (11).

The data show that there is a consistent uptake of blood glucose by the lactating mammary gland under the given conditions (table 2). The differences in hemoglobin concentration average only one per cent, and, in the majority of cases, are within the experimental error of the analytical method used. A less extended series of analyses on blood lactic acid as well as on the neutral fat plus cholesterol fraction of the blood plasma indicate that these substances are also taken up by the lactating mammary gland in appreciable amounts under the experimental conditions described. Further data (unpublished) on the respiratory quotient of the mammary gland of the nembutalized goat show a constant figure, varying but little from the value of 1.09. It thus appears that the rather wide variations in the respiratory quotient of the intact mammary gland previously encountered by Graham *et al.* (12) and Shaw (13) may be eliminated to a large extent by nembutal anesthesia.

SUMMARY

It was shown that goats maintained under nembutal anesthesia continue to secrete milk of normal composition at the normal rate. Comparisons

between arterial and mammary venous blood samples drawn from goats anesthetized with nembutal showed that the uptake of milk precursors continues under these conditions. In view of these results it was pointed out that the adverse effects caused by excitement of the animal while drawing arterial and venous blood samples may be eliminated by the administration of nembutal.

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VARIATIONS IN BULL SEMEN AND THEIR RELATION TO FERTILITY*

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With the wide-spread use of artificial breeding in dairy cattle the characteristics of the semen of the dairy sire and their relation to fertility have become of great interest. The accurate evaluation of the fertility and longevity of a sample of semen at the time of collection would be a useful tool in artificial insemination circles. However, no single satisfactory method of making such evaluation has yet been presented. Various methods have been proposed for determining the fertility of the bull from routine examinations of his semen and the principles of such methods are generally applied in the evaluation of a single sample.

One of the earliest requirements of fertile semen was motility. Donham *et al.* (6) found that semen below normal in motility was less than half as effective in producing conception as was semen of normal, 90 per cent or more motility. Although motility of the spermatozoa was considered important by Williams, W. W. (15), Williams, W. L. (14), Lagerlöf (10), Sciuchetti (13) and others, they did not consider motility alone a reliable index of fertility. Davis (4) believed initial motility of the spermatozoa to be the best single evidence of viability. The duration of motility in stored semen was reported by William, W. L. (14) and Comstock (2) to be a good index of fertility. Comstock (2) and Comstock and Green (3) also reported that the rate of glycolysis of fresh ram semen was proportional to viability of semen and proposed evaluating the semen from its rate of glycolysis in conjunction with its density and percentage of abnormal spermatozoa. Walton and Edwards (18) reported that the initial respiration rate of bull semen was proportional to the breeding efficiency of the bulls.

Examinations of the stained spermatozoa have been reported by many investigators to be helpful in determining fertility. There is considerable disagreement upon the number of abnormal spermatozoa compatible with good fertility, however. Williams and Savage (16, 17) found no highly efficient breeding bulls with over 17 per cent abnormal spermatozoa. Lagerlöf (10) stated that bulls of good fertility produced not more than 18 per cent abnormal spermatozoa. Kuhne (9), Generales (7), and Sciuchetti (13) stated that fertile bulls produced not over 25 per cent abnormal spermatozoa. Some of this disagreement may be due to the differences in opinion as to what constitutes abnormal spermatozoa. This method, however, is subject

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to the same criticisms as motility determinations in that it is only a partially reliable index of fertility. Williams and Savage (16) found demonstrable morphological changes in the semen of only one-third of the poor breeding bulls they examined. Biometrical study of the spermatozoan-head length variation was shown to be indicative of the bull's fertility by Lagerlöf (10), Williams and Savage (16), and Savage, Williams and Fowler (11). The coefficient of variation of head lengths of spermatozoa from bulls of good fertility was not over 4.0.

Another property of the semen which may have some bearing on its fertility is pH. Schneerson (12) and Kuhne (9) reported that pH of the semen should be below 6.60; however, Davis and Williams (5) found that a large majority of the ejaculates from 11 fertile bulls was alkaline in pH.

The properties of semen produced by a bull are not constant. Hence the evaluation of his fertility does not insure the fertility of every sample of semen he produces. This variation in properties of semen has been reported by Lagerlöf (10), Donham and co-workers (6), Sciuchetti (13), Davis and Williams (5), Bartlett and Perry (1) and others. The variation in performance of different bulls has also been pointed out.

This study was made to determine the normal variation in certain properties of semen collected regularly from several bulls of varying degrees of fertility and to note the relation of fertility of the semen to its measurable characteristics.

MATERIALS AND METHODS

The ten bulls included in this study were all in regular service at the University of Missouri dairy herd. They ranged in age from one and one-half to nine years. The Jersey, Guernsey and Holstein-Friesian breeds were represented. Care and management of all bulls were practically the same.

The breeding records of each bull included all services, both natural and artificial, to cows with good breeding histories along with the number of conceptions secured. Pregnancies were determined by examination and by failure of the cows to come in heat after service. The period included in the tabulation of the breeding records was the year prior to April 1, 1940, or such portion of that time as the bull had been in service in the University of Missouri herd.

The semen was collected by use of the artificial vagina as described by Herman and Ragsdale (8). Prior to January, 1940, semen was collected intermittently, but thereafter collections were made regularly twice a week, with the exception of bulls 8, 52, 53, and 47 from which samples were obtained at varying intervals. The bulls were handled as nearly as possible in the same manner at each collection. It was tried to prevent their mounting until they were well stimulated as evidenced by drippings from the sheath. In some cases this was not possible. Often if a thin, watery sample

was secured, a second ejaculate collected immediately was of normal consistency. The semen was collected in a warm collecting tube and not cooled before the initial examinations were made. This varied from 10 to 30 minutes after collection. At that time the semen sample was divided and part of it was stored undiluted in a refrigerator at 40° Fahrenheit. The rest was kept for observation and experimentation.

Notes were made as to the appearance and consistency of the fresh semen, and the volume of each ejaculate was recorded. The concentration of spermatozoa was determined by use of a haemacytometer and pH was determined by means of a Beckman glass electrode pH meter. A smear was made of each sample of semen and stained five to ten minutes with three per cent aqueous Rose Bengal solution. The stained spermatozoa were then examined at 1075 × magnification for morphological abnormalities. The semen was rated for motility initially and at intervals during storage. All motility examinations were made at 100° Fahrenheit in a microscope stage incubator using a 250 × magnification. Motility was rated according to its vigor at 0 to 5. The very best motility was rated 5. No motility was 0. Semen in which the motion was largely weak and oscillatory and in which less than 40 to 50 per cent of the spermatozoa seemed to be in motion was rated 1. Ratings of 2, 3, and 4 represented progressive degrees of spermatozoan activity between the ratings of 1 and 5.

OBSERVATIONS

The results of examinations of 256 samples of semen collected from the 10 bulls were tabulated, and the average values for each characteristic of the semen of each bull were calculated. These averages are given in table 3 along with the bull's breeding ratios. Tables 1 and 2, showing records of semen examinations of two bulls, are presented to illustrate the wide variation in properties of the semen of the same bulls at different ejaculates. Similar records were prepared for all the bulls, but the data were too voluminous to be presented here in their entirety. The records of these bulls are representative of variations shown in records of the other bulls. The records show wide variability in nearly all characteristics of the semen of these two bulls, though semen of bull 49 was less variable than that of bull 50.

The initial motility rating showed the least variation of the characteristics of the semen examined. With the individual bulls it was either uniformly good or uniformly poor. Two bulls which consistently produced semen of poor initial motility were of poor fertility, but not all bulls which produced semen of good initial motility were of high fertility. For most bulls a very large percentage of the spermatozoa had the power of vigorous motility at ejaculation. The duration of vigorous motility under storage conditions was quite variable, however, as is shown in the column listing the maintenance of 2 motility. The hours which a motility rating of 2 or better

TABLE 1

Record of semen examinations of bull No. 50

Date of collection	Appearance of semen	Volume	Concentration	pH	Initial motility rating	Maintenance of 2 motility	Abnormal spermatozoa per 1000				
							Total	Tailless	Coiled tails	Pyriform	Other abnormals
		cc.	*1000/cu.mm.*			*hours*					
1–31–40	Normal	5.5	1248	5.95	5	144	225	15	6	186	18
2– 5–40	Thin	3.0	544	6.25	4	120	357	18	246	87	6
2– 8–40	Thin	5.7	464	7.00	5	24	165	78	39	27	21
2–15–40	Normal	8.0	752	7.80	3	0	90	12	21	45	12
2–19–40	Normal	4.4	972	6.25	5	72	57	12	15	30	0
2–22–40	Normal	4.5	192	6.45	4	168	414	15	234	144	21
2–27–40	Normal	0.5	1280	6.65	3	.....	246	21	135	81	9
2–29–40	Thin	3.2	680	6.70	5	6	117	18	33	63	3
2–29–40*	Normal	7.5	1040	6.40	5	48	126	12	36	75	3
3– 4–40	Thin	4.5	592	6.45	5	16	129	12	72	45	0
3– 5–40	Clear	2.5	56	6.55	2	0	135	21	24	66	24
3– 5–40*	Thin	5.0	600	6.55	5	144	246	21	105	114	6
3– 7–40	Normal	6.0	1040	6.40	5	120	213	3	33	168	9
3–11–40	Normal	4.0	896	6.40	4	24	426	63	87	276	0
3–14–40	Normal	4.0	724	6.55	4	72	249	24	69	147	9
3–14–40*	Normal	9.0	800	6.50	4	96	294	18	135	141	0
3–18–40	Normal	2.5	1096	6.20	5	144	234	30	72	129	3
3–21–40	Thin	4.0	672	6.55	5	24	228	15	93	111	9
3–25–40	Normal	2.6	1160	6.35	2	16	330	90	72	168	0
3–28–40	Normal	3.0	1160	6.20	5	24	183	24	36	123	0
3–28–40*	Normal	7.5	704	6.30	5	24	237	99	12	126	0
4– 1–40	Clear	3.5	160	6.50	3	0	141	90	15	30	6
4– 5–40	Thin	3.0	144	6.50	1	0	126	54	6	66	0
4– 5–40*	Thin	5.2	360	6.45	5	24	120	51	21	48	0
4– 9–40	Thin	3.0	576	.....	5	20	231	15	51	132	33
4–13–40	Thin	3.0	304	6.60	4	24	273	48	18	207	0
4–13–40*	Normal	5.0	856	6.45	5	144	312	126	27	159	0
4–17–40	Normal	4.0	608	.....	5	120	192	51	36	102	3
4–20–40	Normal	8.5	960	6.20	5	168	162	36	30	90	6
4–30–40	Normal	6.5	1104	6.35	5	168	201	27	12	162	0
Averages		4.62	724.8	6.48	4.27	67.4	215	37	60	111	7

* Second ejaculate.

TABLE 2

Record of semen examinations of bull No. 49

Date of collection	Appearance of semen	Volume	Concentration	pH	Initial motility rating	Maintenance of 2 motility	Abnormal spermatozoa per 1000				
							Total	Tailless	Coiled tails	Pyriform	Other abnormals
		cc.	*1000/cu.mm.*			*hours*					
1–10–40	Normal	4.5	520	6.40	5	96	129	39	84	3	3
1–13–40	Thick	3.5	608	6.15	5	48	237	27	186	15	9
1–17–40	Normal	4.6	944	6.25	5	6	87	30	48	3	6
1–20–40	Thick	7.0	1744	6.60	3	6	48	9	33	3	3
1–24–40	Normal	3.7	992	6.70	3	240	372	6	366	0	0
1–27–40	Normal	3.5	336	6.40	5	72	96	42	36	6	12
1–31–40	Normal	11.0	728	6.45	2	96	546	54	489	0	3
2– 3–40	Thick	5.0	1624	5.95	5	144	129	33	93	3	0
2– 6–40	Normal	4.5	1272	6.10	5	72	84	39	39	3	3
2–10–40	Thick	3.5	880	6.20	5	120	72	39	24	3	6
2–13–40	Normal	3.1	816	6.40	5	120	114	45	66	0	3
2–17–40	Normal	1.7	1000	6.60	5	168	48	15	30	0	3
2–20–40	Normal	3.9	816	6.20	5	216	78	27	48	0	3
2–24–40	Normal	3.5	728	5.95	5	160	69	12	48	6	3
2–24–40*	Normal	4.0	816	6.05	5	144	84	21	57	6	0
2–27–40	Normal	3.3	1296	6.05	5	144	114	60	51	0	3
3– 2–40	Normal	2.8	800	6.25	5	144	126	18	108	0	0
3– 2–40	Normal	4.0	1280	6.20	5	168	30	18	6	3	3
3– 5–40	Normal	3.0	1344	6.25	5	48	51	9	39	3	0
3– 9–40	Thick	4.5	960	6.20	5	120	90	18	63	3	6
3–12–40	Normal	5.0	1140	6.10	5	144	117	33	78	0	6
3–19–40	Thick	6.0	1408	6.20	5	72	63	3	45	12	3
3–26–40	Normal	4.0	1640	6.25	5	72	144	0	144	0	0
3–30–40	Normal	5.0	880	6.10	5	72	87	36	45	0	6
4– 2–40	Normal	3.7	616	6.40	5	72	60	18	42	0	0
4– 6–40	Normal	6.0	2032	6.05	5	168	36	3	15	6	12
4– 9–40	Normal	6.5	1392	6.25	5	288	81	6	69	6	0
4–13–40	Normal	4.0	1064	6.30	5	96	60	27	24	9	0
Averages		4.46	1059.86	6.25	4.75	118.4	116	25	85	3	4

* Second ejaculate.

was maintained were determined from the last time at which a motility rating of 2 was observed. Thus if the motility rating at the second examination were 1, the time motility of 2 was observed would be only the initial examination or 0 hours. Although the duration of 2 motility seemed to be quite variable, apparently irrespective of other properties of the semen, such as pH, percentage of abnormal spermatozoa, and concentration, it was roughly correlated with the initial motility of the semen of any one bull. This relationship is shown quite well in the semen of bull 50. Though not all the samples which had an initial motility rating of 5 survived for a long period, none of those which rated motility of 3 or less initially had a motility rating above 1 at 24 hours. This did not hold true for all samples from the bulls (as notice two samples from bull 49 rating motilities of 2 and 3 which kept 2 motility for 96 and 240 hours, respectively) but in a large number of cases the semen of any one bull which was markedly below his normal in initial motility was also below his normal in survival with good motility.

Wide variations were observed in the percentage of abnormal spermatozoa in semen. Except for the first few collections from bull 49, the morphological variations in his semen were relatively slight. On the other hand, the semen of bull 50 varied greatly in percentage of abnormal spermatozoa, as is shown in table 1. For most of the bulls the variations in abnormal spermatozoa were largely due to a relatively large increase of the predominating type of abnormality rather than the same increase of all types. Thus most of the variations for bull 49 were due to an increase in coiled tails, but for bull 50 the increases were mainly pyriform heads.

The pH of semen samples from the same bull was subject to considerable variation. The variations in pH of the semen of bull 49 were not as great as those in semen of bull 50. The bulls whose semen varied most in pH (such as bull 50) also produced semen which was quite variable in consistency and concentration. On the other hand, those bulls (such as bull 49) whose semen was more nearly constant in consistency produced semen of less variability in pH. From this observation it appears that the pH of the semen is regulated by the amount of secretion from the accessory sex glands. An examination of tables 1 and 2 clearly shows, however, that concentration of spermatozoa in the semen cannot be predicted accurately from the pH.

The volume of the semen and concentration of spermatozoa were both subject to variation. A comparison of these two values in tables 1 and 2 shows that they were not correlated significantly. A small sample of semen was just as likely to contain a low concentration of spermatozoa as a high one and vice versa.

The comparison of fertility of various samples of semen from the same bull with their characteristics would have been valuable to indicate the properties of semen most indicative of its fertility. Unfortunately, not

enough cows were bred to any one bull to make such a study of significance. Hence, the breeding records and semen examinations of different bulls were compared in order to find the properties of semen most nearly correlated with fertility. These comparisons are presented in table 3. The bulls are listed in the order of their breeding efficiency. Bull 56 served only two cows, hence his apparently perfect breeding record is not comparable with the records of the other bulls which each included from 12 to 52 services per bull.

Since the percentage of abnormal spermatozoa has been presented as an index of a bull's fertility, it is of interest to study first this property of the semen of the various bulls. The breeding results with bulls in this herd have been contrary to previous ideas in that two bulls (8 and 50) which produced a large number of abnormal spermatozoa have been highly efficient while two bulls (55 and 53) which produced few abnormal spermatozoa have been of poor breeding efficiency. On the other hand, one bull (52) which produced a very high concentration of abnormal spermatozoa most of which were coiled tailed, was of very low fertility. The average percentage of abnormal spermatozoa for semen of bull 8 (35.8) is abnormally high. During the first few collections from this bull he was in poor condition and had recently been shipped a long distance. These collections of semen, although fertile, were very high in abnormal spermatozoa, above 40 per cent. Most of his later semen was below 30 per cent abnormal spermatozoa. No distinction was observed as to the type of abnormality most often associated with low fertility. Coiled tails were predominant in the semen of bulls of both good and poor fertility. A large percentage of pyriform heads was observed in semen of bulls 8, 50, and 47, all of good fertility; so this type of abnormality is evidently of no more consequence in causing infertility than are coiled tailed spermatozoa. None of the bulls produced a very large percentage of tailless spermatozoa, though all produced some. Abnormalities of the middle-pieces, undeveloped spermatozoa, and other abnormal forms included under the heading "other abnormals" were rare and probably of little significance.

The average volume, concentration, and pH of the semen did not show significant differences in those properties of the semen from these bulls of poor versus good breeding efficiency. None of the bulls was considered abnormal in any of those characteristics, however. The variation in average volume of the ejaculates among the different bulls was closely related to the relative size of the bulls within their breed.

The average initial motility ratings varied among the bulls. Bull 52 consistently produced semen which was low in initial motility and this bull was of poor fertility. Bulls 55 and 53, also of poor fertility, however, produced semen which was consistently of good initial motility. Hence, good initial motility in itself is not an accurate criterion of fertility of the bull.

TABLE 3

Comparison of the breeding records and examinations of the semen of ten bulls used in the same herd

Bull No.	No. of samples	Services per conception	Average results of semen examinations									
			Volume	Concentration	Initial pH	Initial motility rating	Maintenance of 2 motility	Abnormal spermatozoa per 1000				
								Total	Tailless	Coiled tails	Pyriform	Other abnormals
			cc.	*1000/cu.mm.*			*hours*					
56	2	1.00	1.85	748	6.60	4.50	36.0	81	36	17	18	10
50	41	1.21	4.56	684	6.50	3.90	74.7	236	38	60	128	10
48	34	1.29	3.98	1218	6.43	3.94	32.7	139	60	73	3	3
54	36	1.31	3.59	812	6.48	3.72	52.4	157	28	110	12	7
8	17	1.33	1.64	943	6.55	4.24	44.8	358	44	146	164	4
49	28	1.38	4.46	1060	6.25	4.75	118.4	116	25	85	3	3
47	23	1.46	6.02	723	6.38	4.14	41.4	170	41	53	70	6
55	32	2.44	4.78	947	6.41	4.29	21.3	91	30	21	35	5
52	18	3.33	2.79	1738	6.53	1.78	1.0	597	46	549	0	2
53	25	3.67	5.10	862	6.47	4.46	20.7	131	37	70	17	7

The average initial motility in semen from bulls 50, 48, and 54 was not as high as the average for the other bulls of good breeding efficiency. These were the bulls which most often gave a small, thin first ejaculate of low motility but which gave second ejaculates of excellent quality.

The property of the semen which was most significantly correlated with the breeding efficiency of the bulls was the average duration of good motility in the stored semen. This was measured by the time a motility rating of 2 (above 50 per cent of spermatozoa in motion) or better was maintained. It appears significant that although other properties of the semen of poor breeding bulls 55 and 53, did not differ from those of semen from good breeding bulls, the average duration of good motility for these poor breeding bulls was distinctly below that for the bulls of good breeding efficiency. It appears from these results that semen from bulls of good fertility should maintain a high percentage of vigorous motility for at least 30 hours in storage undiluted at 40° Fahrenheit. Those bulls whose semen maintained good motility an average of less than 24 hours were of poor fertility. It also appears that the maintenance of 2 motility in stored semen above 36 hours did not enhance the breeding efficiency. Most of the semen was used for insemination immediately after collection, however; and for purposes requiring storage periods the more viable semen might have shown to greater advantage.

DISCUSSION

This study has again demonstrated the fact that ejaculates of dairy bulls are subject to wide variations in characteristics. These variations occur among separate ejaculates of the same bull as well as among the ejaculates of different bulls.

The cause of the morphological variations among different bulls has been shown by Lagerlöf (10) to be due to genitalian defects, especially defects of the testicles. Morphological variations in the same bull's semen from day to day could hardly be explained in such manner for a healthy bull. The most reasonable explanation seems to be that abnormal spermatozoa are to be found always in bull semen as the result of some normal physiological process, possibly the aging or deterioration of spermatozoa or spermatogonia, and that some times a larger concentration of such abnormal spermatozoa will be in an ejaculate than at other times. The physiological limits of production of such abnormal spermatozoa must be dependent on the individuality of the bull. The data show that for some bulls good fertility is maintained in spite of concentrations of abnormal spermatozoa as high as 30 per cent. When this value exceeds 30 per cent and approaches 50 per cent, as with bull 52, some pathological condition must be present and the breeding efficiency of the bull will be poor. A low percentage of abnormal spermatozoa, however, does not insure good fertility.

The property of semen most nearly correlated with fertility of the bull was the time of survival of vigorous motility under storage conditions. This relationship is to be reasonably expected because time is consumed in the journey of the spermatozoa to the Fallopian tubes and also in release of the ovum. The spermatozoa which will be alive and moving vigorously after such time will have a better chance of fertilizing the ovum than will the weaker ones. The low fertility of semen which is very high in percentage of abnormal spermatozoa can be explained on this basis, too, since it is also often of poor viability. Semen of some bulls which produced few abnormal spermatozoa was also of poor viability; so factors other than morphology must be responsible for the duration of motility of the spermatozoa and thus for their fertility.

The volume, concentration, and pH of the semen within the limits here presented were not correlated with fertility. Evidently, bulls of low fertility may produce semen apparently normal in these properties.

Although initial motility of the semen of the different bulls was not correlated with their fertility, except in samples with very poor initial motility which were of poor fertility, in separate ejaculates of the same bull there was a rough relationship between initial motility and time of survival with good motility. From these facts it appears that the simplest accurate method of determining fertility of any one sample of semen is to 1, assure the fertility of the bull by determining average survival time with good motility (using five or more collections secured over two weeks' time) and 2, assure the viability of any one sample of semen from a *fertile* bull by rating motility immediately after collection. This work thus confirms the observation of Davis (4) that initial motility is the best evidence of viability of semen from a fertile bull. The variation in viability of semen of excellent initial motility is quite wide, however; so from the methods here presented it appears that storage of semen from even the most fertile bulls for periods above two or three days will seldom meet with success, and then only as a matter of chance.

SUMMARY

1. A study of the semen of ten bulls used in the University of Missouri dairy herd has been made and the semen properties compared with the bulls' breeding records.

2. The property of the semen most nearly correlated with fertility was the time of survival with vigorous motility in semen stored at 40° Fahrenheit.

3. Among the different bulls, other properties of the semen such as pH, concentration, volume, percentage of abnormal spermatozoa, and initial motility were not correlated with the bull's fertility or time of survival with good motility except in the case of one bull of poor fertility which produced semen very high in abnormalities and very low in initial motility.

4. Among separate ejaculates from the same bull initial motility was roughly correlated with viability in storage.

5. Wide variations in all properties of the semen were observed, among ejaculates of different bulls as well as among ejaculates of the same bull.

6. It is proposed that a bull's fertility should be rated from examinations of at least five semen samples collected over a period of at least two weeks, and that the suitability for use or storage of a sample of semen from a fertile bull can best be determined at time of collection by examination for motility.

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ADEQUACY OF "HOME-GROWN" RATIONS IN PROTEIN AND MINERAL MATTER FOR GROWTH IN DAIRY HEIFERS*

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The desire for economy in raising dairy cattle replacement stock, as well as in producing milk, has led to an interest in the use of "home-grown" rations. Protein supplements are the chief feeds needed on the average farm in the midwest. By the greater use of leguminous crops for the production of protein-rich hays, silages, and concentrates, the purchase of supplemental feeds may be largely avoided. Contemplation of such a feeding program raises the question of the adequacy of such rations from the standpoint of quality and quantity of protein supplied. Likewise, the mineral needs of the animals must be considered. Huffman[1] has reported that rations consisting of alfalfa hay, corn silage, and the farm-grown grains are inadequate in phosphorus for milk production and lead to inappetence and consequent unsatisfactory practical results. He found that the addition of bone meal corrected the phosphorus deficiency and was effective in keeping the animals on feed.

EXPERIMENTAL

An experiment to study the adequacy of the protein from limited as well as multiple sources and the mineral matter supplied by home-grown feeds was started with Holstein heifers averaging six months of age in January, 1934. Six lots of three animals each were started on the following rations:

Lot	*Roughages*	*Concentrates*	
1	Timothy hay	Corn	500
	Corn silage	Oats	500
		Salt	10
2	Timothy hay	Corn	370
	Corn silage	Oats	370
		Gluten meal	260
		Salt	10
3	Timothy hay	Corn	266
	Corn silage	Oats	266
		Bran	234
		Linseed meal	117
		Gluten meal	117
		Salt	10

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[1] Tech. Bulletin No. 134, Mich. A.E.S., "Phosphorus Requirement of Dairy Cattle when Alfalfa Furnishes the Principal Source of Protein." C. F. Huffman, C. W. Duncan, C. S. Robinson, and L. W. Lamb.

4	Alfalfa hay	Corn	500
	Corn silage	Oats	500
		Salt	10
5	Alfalfa hay	Corn	600
	Corn silage	Oats	200
		Bran	200
		Salt	10
6	Alfalfa hay	Corn	500
	Corn silage	Oats	500
		Bone meal	18
		Salt	10

The animals in all lots were fed according to the same plan of allowing hay, silage, and grain in the ratio of 1:2:1, respectively. Thus a heifer that was fed 5 pounds of hay per day also received 10 pounds of corn silage and 5 pounds of the concentrate mixture. This plan was followed throughout with the exception of lot 3 where it was necessary, due to the bulkiness of the mixture, to increase the allowance of concentrates 8 per cent by weight to give the same nutrient intake as for the other lots.

The nutritive ratio of the total ration was 1:10.7 for lot 1 and between 1:6.5 and 1:6.7 for the other lots.

RESULTS

Lot 1 received a ration similar to that on which too many dairy animals are forced to get along, at least for short periods of time, and which is known to be lower in protein than is considered advisable to feed. This ration consisted of timothy hay, corn silage, corn and oats. During the growing period of approximately 18 months (532 days) after the start of the experiment, these heifers gained from an average weight of 498 pounds to a weight of 1169 pounds, or an average daily gain for each heifer of 1.26 pounds.

Lot 2 received the same roughages as lot 1 but the concentrate portion of the ration was improved by the addition of sufficient corn gluten meal to bring the level of protein intake up to an approved standard. The heifers in this group made an average daily gain of 1.41 pounds each during the 532 days of the growth period following the inception of the experiment.

Lot 3 was fed the kinds and amounts of roughage as was given to lots 1 and 2 but a greater variety of ingredients was included in the concentrate mixture, which included corn 266 parts, oats 266 parts, wheat bran 234 parts, linseed meal 117 parts and corn gluten meal 117 parts. This ration furnished the same amount of protein as was fed in lot 2 but afforded a greater variety of feeds and presumably a higher quality of protein. The gains made by the heifers during the first 18 months on the experiment did not indicate it to be superior to that given to lot 2, since the lot 3 heifers averaged 1.30 pounds gain per head daily, during the 532 days.

In the remaining lots (4, 5, 6), alfalfa hay and corn silage were fed as roughages.

Lot 4 received corn and oats in equal parts, the same as fed to lot 1. The protein supplied by the alfalfa hay enabled these heifers to gain more rapidly than those in lot 1. The average gain was 1.45 pounds per head daily during the first 518 days on experiment.

In lot 5 a phosphorus-rich feed was added to the "home-grown" feeds in the form of wheat bran. The concentrate mixture used was corn 60, oats 20, and bran 20 parts by weight. The heifers receiving this ration gained 1.41 pounds per head daily.

Lot 6 was fed the same as lot 4 except that bone meal was added to the grain mixture of corn and oats at the rate of 18 pounds per ton. These heifers gained at the average rate of 1.46 pounds per head daily during the first 18 months of the trial.

TABLE 1

Feed consumption per unit gain and average daily gains of heifers

Lot No.	Feed consumption per 100 pounds gain				Average daily gain per head
	Concentrates	Timothy hay	Alfalfa hay	Corn silage	
1	451.3	448.6	.....	897.2	1.26
2	393.3	391.6	.....	782.6	1.41
3	455.5	420.8	.....	843.4	1.30
4	381.6	.....	379.0	758.3	1.45
5	390.0	.....	386.9	773.9	1.41
6	376.7	.....	374.3	748.6	1.46

The gains made on the various rations were not widely different. Statistical analysis of variance[2] showed the gain of 1.26 pounds per head daily for lot 1 to be significantly lower than the gains made by the other lots. Among lots 2 to 6 the differences in rate of gain were not statistically significant.

DISCUSSION

Lot 2, with 1.41 pounds as an average daily gain per head, exactly equalled lot 5, and was not significantly behind lots 4 and 6 with gains of 1.45 and 1.46 pounds, respectively. Thus it appears that the unsupplemented corn and oats fed with alfalfa hay and corn silage (lot 4) was fully equal in its protein quality for growth to that supplied by the ration in lot 2 where the corn and oats mixture fed with the timothy hay-corn silage roughage was supplemented by the use of corn gluten meal to bring the nutritive ratio up to approved standards. It further appears that (within the limits of this experiment) the corn protein as furnished by the gluten meal to lot 2, was as efficient in supplementing the basal ration (fed to

[2] Made by Dr. C. Eisenhart, Statistician, Wisconsin Experiment Station.

lot 1) as was the protein supplied in the more complex mixture including wheat bran, linseed meal, and corn gluten meal fed to lot 3.

The use of wheat bran in the ration of lot 5, or of bone meal in the ration of lot 6 failed to show any significant advantage over the corn and oats ration of lot 4 when all three were fed with alfalfa hay and corn silage to growing heifers. No lack of appetite (anorexia) was noted with these heifers at any time in any lot.

On June 27, 1935, after approximately 18 months on experiment, blood samples were collected and the serum was analyzed for Ca and P. Calcium and phosphorus levels were normal in all lots which indicate that the level of intake was fully adequate for growth. (See table 2.)

TABLE 2

Calcium and phosphorus levels in the blood serum of heifers and the daily intake of these elements after approximately 18 months on the respective rations

Heifer No.	Serum Ca	Serum Inorganic P	Daily intake	
			Ca	P
	mg./100 cc.	*mg./100 cc.*	*grams*	*grams*
1	11.50	5.6	14.8	15.8
2	11.50	7.0	14.8	15.8
3	11.30	6.9	14.8	15.8
4	11.00	7.1	14.4	16.9
5	11.25	6.9	15.5	18.1
6	11.60	6.9	16.8	19.7
7	11.70	7.5	17.6	27.2
8	11.25	7.8	17.6	27.2
9	11.00	8.2	17.6	27.2
10	11.60	7.1	40.0	21.8
11	11.85	6.1	40.0	21.8
12	11.80	6.4	43.5	23.2
13	11.15	6.3	44.2	30.2
14	11.10	7.9	40.6	28.2
15	11.55	7.5	37.9	26.3
16	10.65	7.6	37.9	28.7
17	11.80	7.8	40.6	30.0
18	10.90	6.6	44.1	32.2

From table 1 it will be noted that those lots which showed the largest average daily gains were the most efficient in utilizing feed for gain when the total ration fed is charged against the gains made. This is very commonly observed in cases of animals fed for meat production and these data are in harmony with such observations.

SUMMARY

Simple home-grown rations proved to be adequate for growth in dairy heifers. Alfalfa hay, corn silage, and a mixture of equal parts corn and

oats produced excellent gains. The rate of growth was not improved by the addition of bone meal or wheat bran.

Timothy hay, corn silage, and corn and oats furnished too little protein for optimum growth. The simple addition of protein from corn in the form of corn gluten meal promoted as rapid growth as was obtained by using a mixture of greater variety including wheat bran, linseed meal, and corn gluten meal in addition to corn and oats.

COMMON DEFECTS OF ICE CREAM, THEIR CAUSES AND CONTROL; A REVIEW

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In the scoring of ice creams, sherbets, and ices for defects the terms only of texture and body appear to be confusing. In a considerable portion of the research work reported the terms have been used interchangeably as well as collectively under the one heading of body and texture. In the scoring of cheese, texture has been defined as the appearance of solidity; body as the substance or consistency of the solid portion. Texture, by dictionary definition, is "the disposition or manner of union of the particles or smaller constituent parts of a body or substance; fine structure; as, the texture of earthy substances or minerals; the texture of a plant or bone," while body is defined as "the physical structure" of the substance. Turnbow and Raffetto (147), apparently because of the obscurity of the two terms, classify the two types of defects under one heading. Frandsen and Markham (52) state: "There is some difference of opinion as to whether body and texture should be judged together or be considered as two separate characters. . . . Body and texture, whether considered together or separately, are of no little importance, but they are characters which are difficult to describe. In very general terms body may be said to be that quality which gives weight and substance to the product and enables it to stand up well. . . . Texture refers to the grain or to the finer qualities of the product." Larsen and White (70) mention body and texture individually and specify defects in each but do not formally define them. Fish (50) states "the texture refers to the molecular structure. . . . The body of the ice cream refers to the structure as a whole." Ambrose (2) distinguishes between the two, "Texture refers to the size, shape and arrangement of the particles or the structure of the ice cream. An ideal texture is one which is perfectly smooth and entirely free from all graininess. Body refers to the total organized substance or the mass of ice cream as a whole. It is dependent upon the texture and resistance. It may be described as light, good, heavy, or soggy." Downs (44) considers body and texture under one heading. Handy (55) describes texture as relating "to the lightness and fineness or smoothness and grain of the body, depending upon the manner in which the ingredients have been incorporated and held together. . . . Body defines weight in the product as well as the quality which gives it lightness, resistance to melting and firmness." Although listing body and texture defects under one general group, Sommer (126) defines each individually: "texture is the attribute of a substance relating to its finer structure—the size, shape and arangement of the small particles. Body is the attribute of a substance relating to the properties of

the mass as a whole—its consistency or firmness, and in the case of ice cream its melting resistance." In view of these opinions and for sake of convenience, body and texture in the following reviews are considered under one group of defects.

FLAVOR DEFECTS

Trout, White, Downs, Mack and Fouts (144) have compiled lists of off flavors found in ice cream samples used at the Students' National Contests in the Judging of Dairy Products for the period 1927–1938 inclusive. Inasmuch as some of the samples were selected because of specific defects, the percentage distribution probably does not apply to commercial ice cream as a whole, but the defects mentioned are representative of those found in commercial ice creams. During the period named, 80.95 per cent were criticized on the flavor, the percentage distribution being, old ingredient, 23.02; unnatural, 20.14; condensed or cooked, 17.26; lacks fine flavor, 12.95; unclean, 6.47; egg powder, 5.03; lacks flavoring, 2.87; metallic, 2.87; neutralizer, 2.87; too sweet, 2.15; high acid, 2.15; and miscellaneous, 2.15. Smith and Tracy (124) in a study of consumer preferences have shown that as far as desirable flavors are concerned women prefer heavy, well pronounced flavors.

Old ingredient, oxidized, metallic, stale, and *tallowy flavors* are terms used interchangeably to a degree by different judges. Rice (117), in one of the early references to tallowiness, referred to the catalyzing influence of copper and light on the development of this flavor. He noted its development at low as well as at high temperatures, and that products of low bacterial content were particularly susceptible to the defect. His work led him to the belief that the action was chemical rather than bacteriological; that oxygen acted more rapidly than air in causing the defect; that filling cans full and thus reducing the space occupied by air might lessen the difficulty; that the greater the copper content, the less air was required to produce the defect; that tin does not catalyze the action; and that iron may act as the catalyst but to a lesser degree than copper. As remedial measures Rice suggested leaving no space for air in cans, cleaning the vacuum pan thoroughly after use, and exposing milk the least possible to copper surfaces.

An exhaustive abstract on oxidized flavor in milk and dairy products was published by Brown and Thurston (13) in 1940. Much material bearing in general on oxidation of fats has been omitted here because of duplication and because much of it was concerned with dairy products other than ice cream.

In 1931 Dahle and Walts (30) studied the methods of preparing dried skimmilk and the effects of method of preparation on ice cream made from it. Those skimmilk powders made from condensed skimmilk generally scored slightly higher, while atmospheric roll powder, when supplying from

eight to nine per cent of the serum solids yielded an ice cream with a decided milk powder flavor. In the same year Dahle and Folkers (31, 32) reported the frequency with which tallowy flavor was encountered in fat-free strawberry ice cream; that it was found no matter what variety of commercial strawberries was used; that the flavor did not occur consistently; that sterilization of mix and berries did not prevent it; and that the flavor did not occur when spray process skimmilk powder was used but did occur when condensed milk was used. No off flavor occurred when less than 0.8 p.p.m. of copper was present or when the acid in the berries was neutralized to pH 7. Dahle, Walts, and Keith (33) found that either spray process or vacuum roller skimmilk powder could supply as much as 10 per cent of the total serum solids, and atmospheric roller process powder only 8 per cent without imparting an undesirable powder flavor. In 1933 Dahle and Folkers (34) published results of extensive work done to ascertain causes of the frequent appearance of oxidized or cardboard flavor in strawberry and pineapple ice creams. This occurred when either fresh, cold pack, or canned strawberries were used and especially when used in 10 per cent amounts. Doubling the amount retarded its appearance but heating mix, or berries, or both, to 180° F. did not prevent the flavor. Appearance of the flavor was delayed by adjusting the pH to 7. The use of skimmilk powder as serum solids seemed to prevent it while condensed milk seemed to favor its appearance generally when it contained its usual copper content of 1.3 p.p.m. Copper content in condensed milk could be kept down by frequent use of the vacuum pan and by keeping the inside surface well polished. Link, Konen, and Baumann (72) announced in 1935 that the presence in ice cream mixes of 0.28 to 1.39 p.p.m. of copper would cause oxidized flavor to appear in strawberry ice cream in 16 to 51 days, dependent on the amount used. With no added copper the defect appeared in 65 days. Since the defect appeared only during the winter season the authors suggested that rapid turnover in the summer and diet of the cows may be factors influencing development of the flavor.

Smith (125) in 1935 recommended that packaged ice cream be held in storage no longer than a month due to the development of off flavor. In the trials made by the author the flavor developed in vanilla ice cream in approximately one hundred days, but strawberry ice cream was particularly susceptible to the defect, it appearing more quickly than in vanilla, chocolate, or maple walnut. The samples used for the experiment were stored for 16 to 24 weeks at 6 to 20° F. The stale flavor began to develop in the strawberry flavored cream after one to two months in storage, in vanilla in three months, but chocolate and maple walnut were unchanged after four months. The author concluded that age of the ingredients before freezing was more important than storage period. Schricker (121) found the off flavor to develop in vanilla ice cream in four weeks; in chocolate in four to six weeks; and in strawberry in two weeks.

Tracy, Ramsey, and Ruehe (130) in 1933 found the flavors, stale, metallic, and tallowy occurring together in strawberry ice cream. They found fat oxidation to be hastened by the presence of copper salts and a minimum of berries, the latter being true by reason, presumably, of a lack of fiber. Remedies suggested were elimination of copper contamination, use of high quality dairy products, addition of at least 15 per cent of solid pack strawberries and the use of high homogenizing pressures. The same year Ross (118), working with 22 identical mixes, except for milk-solids-not-fat, was unable to find any change in degree of fat oxidation. He was unable to locate oxidizing agents as a factor, nor iron. Some flavors, he found, might wholly or partially mask the off flavor but it was found in control mixes containing no strawberries. Mixes containing condensed skimmilk developed the flavor more quickly than others, probably because of the presence of copper together with any fat oxidation occurring during manufacture. Seism (122) in 1934 held 12 samples each of chocolate, vanilla, and strawberry ice creams at – 25° F., and held a second similar set of samples in an ice cream cabinet. Scorings made at intervals showed that those samples held at low temperatures resisted deterioration. At either temperature chocolate stood up best, vanilla second best, with strawberry deteriorating first in flavor.

Tracy, Ramsey, and Ruehe (131, 132) in 1934 condemned copper as being the most important of the causes of oxidized flavor, and its elimination from the mix as one preventive measure to be taken. Other measures recommended were high homogenizing pressures, heating of apparatus and either soaking the strawberries in mix before use or the use of increased amounts of fruit, or the addition of increased amounts of strawberry fiber. Denseness of the berry pack was thought to be a possible factor. The authors suggested the probability that the strawberry juice contained a catalyst and the fiber a reducing agent. Addition of citric acid to the strawberry juice did not hasten oxidation. The same variety of berries acted differently depending upon the heat treatment given them during canning, and, presumably due to varying fiber content. In desirability for use in ice cream the varieties tested rated from most to least desirable were: Dunlap, Parson Beauty, Gandy, Premier, Gibson, and Aroma. Either two, three, or four parts of berries to one of sugar were recommended as desirable packs. Other fruits than strawberries found to accelerate production of oxidized flavor were oranges, lemons, and pineapple.

Dahle and Josephson (35) found a high copper content in some pineapple products and stated that it contributed to the development of oxidized flavor. They found canned pineapple on the market, however, sufficiently low in copper to be acceptable to the ice cream trade. Sorber (128), writing in 1940, claimed that contamination of several kinds of fruit with copper will intensify the reaction of copper in the production of oxidized

flavor. In 1937, Bird, Willingham, and Iverson (7) stated that the addition of strawberries did not materially increase the amount of copper in a mix; that the development of a stale flavor in ice cream was not serious but that the presence of metallic and tallowy flavors were; that heating the butterfat in the vacuum pan apparently had no effect on the flavor; and that storage of the condensed milk for a week at 32° F. had no effect. The addition of strawberries tended to delay the appearance of off flavor in the ice cream. Presence of copper accelerated the development of the flavor but the authors believe that it is the state of the copper, rather than its mere presence, which affects the flavor production. Stainless steel pans caused less off flavor, and condensed milk from stainless steel pans gave mixes of better quality than those made from dried milk.

Iverson (62), the same year, called attention to the importance of the presence of iron in the mix in the development of tallowy flavor. He stated that the higher this is the less pronounced the off flavor will be, due, he believed, to the iron helping form an antioxidative catalyst through the action of ferrous iron with a milk constituent. He found oxidases in the fruit were not factors in the flavor production. Iodine number changes paralleled oxidative changes, but Reichart-Meissl numbers and acetyl values did not, suggesting the role of the unsaturated fats. Tallowy flavors were more often encountered when whole milk, condensed, or skimmilk condensed were used than when dry milk was used. Either type of condensed milk, when made in a stainless steel vacuum pan, showed a much reduced tendency to develop the flavor. Fruits retarded the tendency to develop the tallowy flavor. Mixes containing less than 1.18 p.p.m. of copper did not develop tallowy flavor; those showing the flavor contained at least 1.8 p.p.m. of copper. If the flavor appears between these copper content mixes, the author ascribes its cause to other factors. He also emphasized state as well as presence of copper as important. In addition to the above, in another publication, Bird, Iverson, Ause, and Willingham (8) state that strawberries contain no oxidases; that fat content of the mix had no effect on rate of development of the flavor; and, that mixes from stainless steel pans did not develop the defect.

With regard to antioxidants for prevention of oxidized flavor, Dahle and Josephson (36, 37) reported in 1937 that the use of 0.5 to 0.7 per cent oat meal flour (Avenex No. 7) would prevent tallowy flavor in strawberry ice cream with 2 p.p.m. of copper present. The use of 0.7 per cent increased viscosity too greatly. The oat flour, when added in amounts of 0.5 to 2 per cent to fresh cream before freezing for storage, reduced its tendency to develop the flavor. The authors recommend 0.5 per cent, and addition to the mix with the sugar. Mueller and Mack (95), the same year, reached similar conclusions. Of several rates used they found 0.5 per cent of oat flour to be the optimum, preventing appearance of oxidized

flavor for at least four weeks. When 0.5 per cent of oat flour was used they found that gelatin should be decreased by 25 per cent. The use of as little as 0.25 per cent oat flour retarded appearance of oxidized flavor during storage but not as efficiently as 0.5 per cent. Also in the same year Musher (100) advised the use of 0.5 per cent Avenex to prevent formation of oxidized flavor in ice cream and recommended reduction of gelatin by 25 per cent when this amount of oat flour was used.

Maack and Tracy (84) reported in 1938 that using oat flour in mixes to which 3 p.p.m. of copper had been added, and in rates varying from 0.1 to 0.5 per cent, 0.5 per cent was necessary to secure sufficient retardation. This amount added to vanilla mix was sufficient to protect it against oxidized flavor for several weeks. The oat flour was helpful in retarding development of the flavor in strawberry ice cream containing 1 p.p.m. of copper but not to the degree it was helpful in vanilla mix. It imparted a slight flavor of oat meal to the mix but this was not unpleasant. The authors recommend mixing the oat flour with the sugar and adding the two together or adding it in dry form at the freezer. An attempt to make and use a water extract of the antioxidative agent was unsuccessful.

Weckel (150) pointed to origination of off flavors from three sources: 1, inferior ingredients; 2, equipment effect; and 3, storage. In referring to oxidized flavor he suggested the use of Avenex or a trypsin preparation as being effective. Burke and Newman (14) also recommended the use of oat flour to the extent of 0.5 per cent with a reduction of gelatin. They found the flour to impart a slight oat flavor.

Dahle and Nelson (38) in 1941 published results of an effort made to isolate from two well known edible antioxidants the material responsible for their antioxidative value. Search was directed particularly towards the phospholipid content and fractions made using several solvents. Isolation of such a concentrate would greatly simplify the use of cereal antioxidants in the ice cream mix. The isolation attempt was only partially successful. The phospholipid fraction and the alcohol extract exhibited greater value than the fractions secured with other solvents. Those from oat flour proved more potent than similar extracts from soya bean flour.

Condensed, powder, and *cooked flavors* result from overuse of particular concentrated products or the use of those products which have been improperly processed. Ambrose (2) found that ice creams made with 12, 14, and 18 per cent of milk solids were at first good in flavor but after two or three weeks in storage developed condensed milk or lactic flavor. These rarely developed when less than 12 per cent of milk solids were used.

Dahle, Walts, and Keith (33) in 1931 pointed out the danger of securing a milk powder taste if more than 8 per cent of atmospheric roller process skimmilk powder or greater than 10 per cent of spray process powder were used in supplying the total solids. The same year Price and Whittaker (106),

studying the use in ice cream of spray process, flake, vacuum roll, and atomspheric roller skimmilk powders found all to be satisfactory, except the last, which gave a cooked, custard-like flavor. In 1931, also, Iverson, Calder, and Chu (63) noted that ice creams made with either roller or spray process skimmilk powders scored higher in flavor after having been stored two weeks than ice creams made with condensed skimmilk. When ice creams made with low concentration plain condensed skimmilk were stored, off flavors developed more rapidly than when made from high concentration condensed skimmilk. Ice creams made from concentrated skimmilk products and unsalted butter developed off flavors more rapidly than ice creams made from sweet cream. In practically all cases the amount of unsalted butter that could be used was limited. Gibson (54) found that the use of "Pro-lac" powder in ice cream yielded a malt flavor and salty taste. Carithers and Combs (15) in studying drum dried versus spray process powder for ice cream found each equally effective in producing a fine flavor when fresh. When held six months before use drum dried powder was much inferior to spray process and imparted a strong, old, stale powder flavor to the ice cream. Iverson (64) is authority for the statement that serum solids may be a fruitful source of off flavors. They may improve flavor, but because of their own pronounced flavor, the use of more extract in the mix is required to cover a portion of the flavor of the serum solids themselves.

Tracy (133, 134) as early as 1923 checked the relative advantages and disadvantages in ice cream of superheated condensed skimmilk. The use of the superheated product resulted in a lowering of flavor score due to the presence of cooked flavor. The use of the unsuperheated milk caused no cooked, condensed flavor. The ice creams used in Tracy's tests varied considerably in fat content but very closely resembled modern ice cream except for a low sugar content of approximately 12 per cent. On storage the superheated showed a tendency to develop both old and condensed milk tastes. The unsuperheated before holding or storage had a flavor more nearly resembling that of fresh milk than did the superheated.

Lucas (73) has stated that some off flavors may be removed from ice cream ingredients, especially from the dairy products, by making the mix in the vacuum pan, and that a fresher tasting mix results due to the use of fresh milk. Reichart and Corley (107) compared fresh and frozen condensed skimmilk in ice cream. After two weeks of storage there was no appreciable difference in flavor but after seven months of storage both were criticized as having a condensed flavor and as "lacking in fine flavor." Crowe, Deane, and Winn (25) could find no difference in the flavor of mixes made with fresh and frozen plain, superheated, and sweetened condensed skimmilk. In work reported from the Kansas Experiment Station (66) finished ice cream made with superheated plain condensed milk or superheated products other than the one mentioned showed a cooked flavor.

Superheated plain condensed milk gave a slightly cooked flavor; superheated sweetened condensed milk gave a pronounced cooked flavor; and superheated mix had a still more pronounced cooked flavor. If sugar was present when the product was superheated a caramelized flavor resulted; if not, only a cooked flavor developed. On the whole, the authors concluded, superheating was detrimental to high quality.

Unnatural flavor. Washburn (148), in the first agricultural experiment station bulletin on ice cream making, stated that flavor in ice cream is due to fat content, freedom from contamination, low acidity, addition of salt, and aging of cream. Bear (4) stated that flavor is affected by quality flavoring materials, richness of cream, taints and kinds of cream, filler, and storage of products; and, that "pure vanilla yields more pleasing flavor than cheap compounds. Natural fruit flavors are better than cheaper grades." Cole (17) recommended that to control flavor defects inferior raw materials cannot be used, inferior flavors or flavor combinations must be avoided, and that storage time must be limited and the storage temperatures low to avert off flavor development. He advised the use of pure rather than imitation flavors in ice cream. Lucas and Merrill (74) in a study of vanilla flavors scored pure extract flavored ice cream over compound and imitation flavored ice cream.

Egg powder flavor, if at all pronounced, is regarded as undesirable in ice cream because it is offensive to an appreciable number of people. Martin and Caulfield (87) have stated that use of 0.5 per cent of egg yolk did not affect flavor of the mix. They advised that egg yolk flavor is objectionable to some people and that it is more noticeable in low than in high solids mixes. Mueller and Button (96) in 1929 asserted that addition of 1 per cent of dry egg yolk to ice cream mix did not injure flavor but that 1 per cent of dry whole egg did. Addition of 1 per cent of dried egg albumin injured flavor by imparting an albumin aftertaste. The addition of either dried yolk or whole egg caused more noticeable improvement in low than in high solids mixes.

Acid flavor may have been more frequently encountered a few years ago because of a belief then that acidity in ice cream should be standardized. Certainly neutralization of partially soured mixes had in some cases been resorted to. Fisher (49) in 1923 wrote that mixes containing 0.19 per cent acid homogenized at 3000 pounds pressure yielded ice cream with fine flavor, but mixes testing 0.25 to 0.3 acidity homogenized at 2500 pounds had a good flavor but lacked freshness. Masurovsky's (89) conclusions were similar: that mixes containing 0.295 per cent acid possessed, when frozen, a disagreeable lactic acid flavor that persisted even after being flavored with caramel. Tracy (135) found that increasing acidity above 0.2 per cent tended towards flavor injury.

Flavors due to sweeteners may or may not be considered as defects.

Davis (40) in 1916 observed that decreasing sugar below normal produced an unsatisfactory flavor; while raising it above normal reduced demand because of its being too sweet to suit the public taste. In 1919, in the first article on ice cream appearing in the JOURNAL OF DAIRY SCIENCE, Frandsen, Rovner, and Luithley (53) stated that corn syrup as a sweetening agent affects the flavor of ice cream favorably when used in proper amounts, but used in excessive degree it imparts a disagreeable glucose flavor. The authors recommended 70 per cent of sucrose to 30 per cent of corn syrup. Corn sugar used alone gave a flat unpalatable flavor, or when used to replace over 50 per cent of the required sucrose. Thirty per cent substitution did not improve flavor. The use of a mixture made by inverting 1 pound of corn syrup and 2 pounds of cane sugar with ¾ pound of water and 1 gram of tartaric acid yielded a syrupy flavor. When used alone, in quantity sufficient to impart desired sweetening value (6.25 pounds per batch), this syrup caused an objectionable flavor, but when 1.25 pounds of sucrose were used with 4.5 pounds of the syrup the resulting flavor was acceptable. Ayers, Johnson, and Williams (3) in 1918 wrote that syrups made from grains contributed a grain flavor to ice creams in which they were used to replace 10 per cent of the sugar normally employed. Some grades of corn sugar on the market at that time produced a bitter flavor.

Williams and Campbell (152) in 1922 found in a consumer preference test that of 443 people a majority preferred ice cream containing 19 per cent of sugar and over 90 per cent preferred ice cream with 16 or higher per cent sugar. Reid (108) in 1924 stated that ice cream containing 12 per cent of sugar was superior in flavor. Lucas, Matsui, and Mook (75), in scoring ice creams containing varying amounts of sugar, considered 15 per cent the optimum, and 17 per cent as being a trifle too much. The inversion of sucrose was studied by Ruehe (119) in 1919. He found that substitution of corn sugar for 20 to 50 per cent of invert sugar was practicable, but that glucose was less satisfactory because of being less sweet and because of flavor. In 1930, Smallfield (123) stated that lower grades than light amber of honey lent too strong a flavor to ices and sherbets. He found it undesirable to use honey in whole milk sherbets on account of its not blending well but found it satisfactory when mix was used to supply the dairy product in them. Tracy *et al.* (136, 131) stated that corn sugar had little effect on flavor and that it had no tendency to prevent or delay the development of tallowy flavor. Corbett and Tracy (22) in 1936 corroborated their earlier statements on corn sugar by stating that it had no detrimental effect on flavor. Corbett and Tracy (23) and Tracy (137) in 1939 stated that consumer preference tests indicated that dextrose was 0.83 as sweet as sucrose and that consumers thought dextrose sweetened ice cream richer when one fourth of the sucrose per pound per batch was replaced with 1.43 pounds of dextrose. Cooley,

Reid, and Hall (21) in 1940 replaced one fourth of the sucrose in ice cream mixes with equal amounts of dextrose. Four hundred consumers found the resulting ice cream as desirable in flavor and in some instances more so than when sucrose only was used as the sweetener. Dahlberg and Penczek (27) found a new type of liquid corn syrup gave to ice cream a fresher, fuller flavor than sucrose. Dry corn sugar gave a slight flat flavor due to low sweetening value. Tracy (138), working with "Sweetose," a high conversion corn syrup, used it to replace 33 to 50 per cent of the sucrose in ices and sherbets. He found it to improve some fruit flavors, especially pineapple. When used to replace 25 to 33⅓ per cent of the sucrose it had no effect on flavor.

Flavor defects in chocolate ice cream. Caulfield (16) in 1930 studied the effect of several commercial chocolate syrups for ice cream and found most of them very high in sugar. Adjustment of composition of the mix to allow for the composition of the syrups corrected the difficulty. The syrups produced extremely variable flavors which were in no case as desirable as those obtained from the use of high grade chocolate liquor or cocoa. Tracy, Ruehe, and Tuckey (139) in 1930, in studying chocolate liquor versus cocoa for ice cream, found that increased serum solids and fat produced a more pleasing flavor. By increasing the sugar content to 17 per cent a bitter flavor was avoided. Reid and Painter (109) found that when using in excess of 17 per cent of sugar in chocolate ice cream the product lacked chocolate flavor and that the use of chocolate flavoring produced a true chocolate flavor.

Maybee (90) in 1939 stated that flavor strength in cocoas and chocolates depends on the fineness of grinding: the more finely the product is ground, the stronger the flavor. Meeker (91) stated in 1940 that a portion of the flavor of cocoa beans lies in the cocoa fat. This conclusion was drawn from results of many tests made by a large chocolate manufacturing firm in which, using the same blend of beans for each, ice creams made with chocolate liquor were better than ice creams made with cocoa or a mixture of the two. By calculation, the same amount of non-fatty constituents was used, thus introducing the same amount of non-fatty flavor plus any carried in the additional cocoa fat. It was claimed that chocolate liquor flavored ice cream possessed a truer chocolate flavor. Lucas and Gould (76) in an extensive series of consumer tests of preference for individual varieties of cocoa beans ground into liquors found the majority of consumers wanted chocolate of pronounced flavor. South American bean liquors were preferred. Ash, pH, and cocoa fat content of the beans used had no influence on flavor.

Miscellaneous flavor defects. Bishop and Murphy (9), in early studies of homogenization, stated that the process produced a richer flavor in ice cream. Ambrose (2) observed in 1923 that richness of flavor was increased by increasing the per cent of fat provided the milk-solids-not-fat were

reasonably high. If these were as low as 6 per cent an increase of fat from 8 to 14 per cent did not affect richness. In this respect fat and milk-solids-not-fat were supplementary. Increasing fat beyond 14 per cent did not enhance richness of flavor. Lucas, Matsui, and Mook (75) found an increase of 2 per cent of fat above 10 and up to 14 per cent of fat increased flavor score three points. Eight per cent fat ice creams were described as thin and watery. From 12 to 14 per cent butter fat was regarded as ideal.

Tracy (140), in 1930, seeking to locate a bitter, woody surface taint appearing after two to three days storage in whipped cream used on fancy goods, found it to be an absorbed flavor coming from wood surfaces exposed in ante and hardening rooms. Yellow pine was found to be especially faulty but ash was also contributory. Woods free of odor when dry were found to produce it when wet. Sealing ice cream containers as nearly air tight as possible was recommended. Fabricius (48) is authority for the statement that agar and gum, used at times to control overrun, may impart undesirable flavor to ice cream. Baer (4) in 1916 stated that old, tainted, and sour cream carry their respective flavors into the finished ice cream and that excessive stabilizer can usually be tasted. Williams (153) in 1917 wrote that in some cases gelatin was found to give ice cream an undesirable taste and in some cases it tended to blend the fruit and cream flavors. When used in excessive amounts it subdued a portion of the fruit flavor. Tuckey (146) found that low grade gums gave an off flavor to ices and sherbets. This flavor might be described as "medicinal" and bitter. Plastic cream, according to Foskett and Mack (51), in trials made by them, did not give as good flavor to ice cream as sweet or frozen cream, but was better than butter as a source of fat. Joslyn and Cole (65) in 1938 recommended against the use of fruits high in tannic acid. They stated, also, that high fat mixes tended to mask the flavor of fruit in fruit ice creams.

Reid (110, 111) has said that serving temperatures affect flavor of ice cream. Vanilla and strawberry were best served at 16° F. and chocolate at 10° F. Served at 16° F. the flavor of the chocolate was too pronounced. All flavors served at lower temperatures lacked flavor and were too cold to be most palatable. The later work recommended as serving temperatures 10° F. for ice creams of mild flavor, and 16° to 18° F. for those of more pronounced flavor.

BODY AND TEXTURE DEFECTS

Trout, White, Downs, Mack, and Fouts (145) compiled criticisms and their incidence in scoring ice creams in the National Dairy Products Judging Contest and found that 74 per cent of the 104 samples were criticized for body and texture. The most frequent criticism was that for coarseness, 22.6 per cent. Incidence of other defects in percentage were: curdy whey off, 18; weak body, 15.8; crumbly, 9.6; does not melt, 8.9; icy, 8.2; soggy, 8.2; fluffy, 6.2; and buttery, 2.1. Few perfect scores were given and the average cut in body and texture was two points.

Cole (18) stated in 1932 that texture and crystal structure were synonymous. He preferred to determine structure microscopically, using a rotary microtome to cut a section, mounting it in a fixative on a glass slide, magnifying 100 times, and reflecting light up through the slide by means of a mirror. He found that rate of freezing affects size of ice crystals, that proper freezing and storage may correct many texture defects, and that smoothness of texture as determined by size of ice crystals does not correlate with size or volume of air cells. Cole and Boulware (19) reported in 1940 a study, made by means of a dilatometer and organoleptic tests, of ice crystal formation in ice cream. They state that texture defined by examination microscopically would depend on ice crystal size and structure, and by organoleptic tests would depend on size of ice crystals, temperature of sample, and constituents supplying lubricant-like properties. High fat mixes were smooth but did not necessarily contain smaller ice crystals. Composition remaining the same, ice crystal size would influence smoothness. Butterfat often masked coarseness, as when high fat ice cream is frozen in a batch freezer where large ice crystals are formed. The authors found milk-solids-not-fat retarded growth of ice crystals more than fat and that, if ice crystal size alone were responsible for smoothness, milk-solids-not-fat were more important than fat. They suggested that this may be due to the affinity of the hydrophylic colloids of milk for water and its effect on ice crystal formation. Increase of fat and milk solids smoothed texture and reduced size of ice crystals. When fat content was held constant, a lowering of skimmilk solids increased ice crystal size with consequent coarseness. This effect was greater when fat was varied. Skimmilk solids retarded freezing more than did fat. Fat content had a greater effect upon texture, judged organoleptically, than a reduction of ice crystal size determined microscopically or a retardation of ice crystal growth measured by the dilatometer. With composition held fairly constant, smoothness of ice cream, determined by organoleptic tests, correlated closely with ice crystal size except where the ratio of fat to milk-solids-not-fat was very high or very low. Smith and Tracy (124) in 1938 published results of a consumer preference test. One hundred seventy-nine questionnaires were answered. The preference was for smooth texture and body, medium fat content, high serum solids, and medium to high sugar. Women preferred a heavy body ice cream and seemed to prefer the use of a stabilizer.

Coarse, granular, icy defects in ice cream have received much attention from students of ice cream making. Penny (105) in 1892 wrote that when cream from the Cooley and centrifugal systems of creaming were used in making ice cream the former proved slightly better in insuring smooth texture. He believed the treatment cream received after separation, such as age, temperature, and acidity, was more important than separation. Alex-

ander (1) in 1909 found coarseness developed in ice cream without gelatin and that gelatin hindered coagulation of casein much the same as it hinders coagulation of silver nitrate before precipitation with hydrochloric acid. Washburn (148) in 1910 ascribed good body as being due to sufficient fat, fillers, and thoroughly cooled cream; and fine texture to richness of cream, aged cream, proper freezing, and gelatinous fillers. He asserted that a filler is used to give body, and a binder to prevent coarseness when the ice cream is held. Mortensen (92) in 1911 stated that iciness and coarseness in ice cream were caused by improper packing, holding too long, absence of filler, too thin cream, and packing while too soft. Mortensen (93) in 1915 wrote that freezing the mix too soon after pasteurization gave a coarse body.

The same year, Brainerd (12) stated that smoothness is closely related to the time an ice cream will retain its texture and depends on the amount and finesness of division, within limits, of the solids present and the size and distribution of the ice crystals. Ice crystal size was regulated by the number and nearness of finely divided constituents that, interfering with ice crystal formation, held the size to a minimum. Colloidal solids, other than fat and well emulsified fat, both in a very fine state of division were best for ice cream, hence the value of homogenization. Fineness of division of the solids tended to prevent separation of the solids from the liquid phase and bore a strong correlation to the keeping qualities of the mix. This was true up to the point at which the solids merged into true solution. Bishop and Murphy (9) in 1913 advised that ice cream made from homogenized cream possessed a much improved body and smoother texture. Baer (5) the next year published results in which he stated that too rapid freezing caused soggy, coarse grained ice cream and too slow freezing caused an open, foamy texture. Aged mixes gave firmer, smoother ice creams. Raw cream produced a smoother texture than pasteurized cream but homogenization and aging corrected this deficiency in pasteurized cream. Solids, in addition to those present in cream, had to be added to give desired body. Two years later Bear (4) published results secured from 600 freezing tests in which he averred that body (general firmness) and texture (smoothness) was influenced by age, richness, and kind of cream used, serum solids content, and kind and amount of filler. Aging of cream for 24 to 48 hours at low temperature was recommended for production of smoothness. Richness of the creams used ranged from 8 to 30 per cent, but if below 18 per cent the ice cream was weak in body and coarse in texture. The thinner the cream the more filler was required. Freezing too rapidly caused coarse texture and weak body; too slowly caused lack of smoothness because the mix was not whipped properly. Excessive over-run resulted in poor body and texture, the latter being open, light, and foamy.

Mortensen (94) stated in 1918 that where raw cream was used for ice cream the texture of that made from fresh cream was slightly inferior to

that made from aged cream. The body of that made from fresh cream was coarse and weak; from 24-hour-old cream, fairly satisfactory; and from 48-hour-old cream, a trifle light. When homogenized, fresh and 24-hour-old cream produced very good body. Baer (6), the same year, stated the addition of 2 per cent of skimmilk powder to emulsified cream retarded crystallization of the ice cream. During emulsification with steam, water to the extent of 10 to 15 per cent was added to the mix, due to condensation. This resulted in coarseness of texture.

Williams (153) stated in 1917 that gelatin, repeatedly heated, lost some gelatinizing power and caused weak body. He suggested that it be used the same day prepared and that it be heated to 160° F. before addition to the mix. When ice cream, made with and without gelatin, was stored 24 hours the latter became unsalable because of coarseness and granulation. When held for six months the gelatin-made ice cream was much preferable both in flavor and body. In 1923 the statement was made in a report from the New York Experiment Station (102) that air cells in ice cream retain their size and shape due at least partially to gelatin and homogenization. These investigators found that fat had little effect in ice cream although it retarded growth in size of ice crystals. Air cells that were small and uniform in size resisted better than large cells the pressure of freezing, thereby increasing smoothness of texture.

Fisher (49) found mixes containing 0.19 acid homogenized at 3000 pounds pressure, and mixes containing 0.25 to 0.3 acid, homogenized at 2500 pounds, produced ice cream of fine body and texture. He believed the theory of the necessity of acidity for smoothness and overrun incorporation to be false.

Ambrose (2) in 1923 made mixes containing 8, 10, 12, and 14 per cent fat and 6, 10, 12, 14, and 16 per cent milk-solids-not-fat, respectively, with 12 per cent sugar and 0.5 per cent gelatin. When low milk-solids-not-fat and milk solids were used texture was coarse and body light. When high the body of the ice cream was soggy. The effect of total milk solids seemed to depend upon whether they were high in fat or solids-not-fat. With milk-solids-not-fat at the proper level the addition of fat improved flavor and body and smoothed the texture. The author added, however, that there is an optimum and upper limit for fat content. Low total milk solids, 12 to 20 per cent, caused coarse texture and light body; high, 28 to 32 per cent, caused heavy, soggy body. Per cent of these was not so important as kind. Six per cent of milk-solids-not-fat caused very coarse texture and light, snowy body, due to small internal resistance to churning during freezing, while 18 per cent caused velvety texture but very heavy, soggy body. Good results lay between these extremes. Betwen fat and milk-solids-not-fat, the latter was the more important in control of body and texture. For good commercial ice cream the author recommended 8 to 14 per cent of butterfat

and 10 to 12 per cent of milk-solids-not-fat. Tracy (135) in 1924 asserted that, overrun being held at a constant level, an increase in fat greatly improved texture of ice cream.

In 1928 De Pew (42) stated that viscosity variations in the mix, due to varying homogenizing pressures, caused great variation in smoothness of ice cream, and that such viscosity necessary for ease in handling and the securing of optimum overrun was best. More than that was deemed unnecessary. Reid and Skinner (112) in 1929 homogenized commercial ice cream mixes at varying pressures using single and double stage valves. Except where excessive pressures were used, aging and increased pressure improved both smoothness and closeness of texture. Reid and Garrison (113) found smoothness of ice cream increased as the temperature at which it was frozen decreased. Length of freezing time was of minor importance. Mixes of higher milk-solids-not-fat required lower homogenizing pressures than those of lower content.

Hening (56) in 1930 reported that aging the mix longer than two to four hours had no effect in improving texture except in a very few cases. Lucas (77) found a year later in using a modern freezer equipped with sufficient beaters that aging had no apparent effect on body and texture although it increased speed and amount of air incorporation. In 1933 Mueller and Frandsen (97) reported that aging the mix at 68° F. for four hours increased the efficiency of gelatin in ice cream, whether or not the mix was aged later at low temperatures. This resulted in smoother texture.

Munkwitz and Meade (99) in 1931 reported that dull freezer blades lessened freezer efficiency and caused coarse ice cream, and, if very dull, caused an increase in freezing time of 100 per cent. The authors drew ice cream at 80 per cent overrun, hardened it for 48 hours, broke it, hardened the surface with dry ice, and photographed it. Coarseness was revealed when the blades were only slightly dull. They advised that running the freezer when empty or with wash water or for freezing ices will dull the blades.

Reid and Hales (114) have stated that crystalline structure of ice cream was affected by composition of the mix and that as these mix constituents were increased texture changed from coarseness to smoothness. Fine texture, as seen under the microscope, was associated with the appearance of uniformly dispersed small, angular shaped ice crystals and jagged air cell boundaries.

Horrall (61) in 1933 listed several factors causing coarse texture. One was the drawing of ice cream in a soft or medium soft state. Heat shocking ice cream at increasingly high temperatures caused increasing coarseness when rehardened. Low storage temperatures smoothed the texture. Ice creams processed at 165° to 180° F. were smoother than those processed at 150° F. Aging had little effect on texture. High gelatin ice creams homog-

enized at low pressure were not as coarse and icy as those with low gelatin content homogenized at high pressure. Increase of gelatin increased smoothness. When gelatin was varied from none to 0.4 per cent the unfrozen serum drained to the bottom of the container making that portion quite icy.

Hening (57) found that when gelatin was not used in the mix, two stage homogenization at 2000–500, 1200–400, and 900–300 pounds pressure, as well as centrifugal homogenization caused coarse ice cream. Addition of gelatin restored the effectiveness of either type of homogenization. Higher pressures than those indicated also increased the effectiveness. Bradley and Dahle (11) in 1933 stated texture is affected by ice crystal size and this by speed of freezing. Consequently, ice creams drawn at the same temperatures from the freezer may vary in the amounts of ice present. Speed of hardening affected texture similarly: the more rapid the rate of hardening the smaller the ice crystal size and the smoother the ice cream. Ice creams from a batch freezer were coarser than from a continuous freezer due to slower freezing with accompanying larger ice crystal size. Texture of batch frozen ice cream was affected by fat content. This was not true of continuous frozen ice cream. Increase in butterfat increased time required for hardening, in turn increasing coarseness. As remedies, the authors recommended air circulation in the hardening room, drawing ice cream at low temperatures, and at low overrun. Dahle (39) stated in 1936 that for improving texture butterfat proved to be more important than serum solids because it offered mechanical obstruction to the formation of ice crystals. Homogenization, by breaking up fat groups, increased the obstruction. Other observations were previously mentioned (11).

Levowitz (71) in 1939 noted that lowering the overrun on ice creams frozen in continuous freezers caused the ice cream to be drawn in a moist condition and that, during hardening, areas froze into lumps of ice. The machine produced a dry surfaced ice cream down to 90 per cent overrun which became increasingly moist to 60 per cent overrun at which lumps of ice began to appear. At 50 per cent overrun the lumps were as large as puffed rice grains. Their appearance was delayed by increasing the total solids of the mix. Erb (46) in 1940 called attention to the drawing of ice creams from the freezer at high temperatures and hardening slowly as being causes of coarseness. An ice cream drawn at a low temperature and hardened slowly was, on the average, equal to one drawn at a high temperature and hardened rapidly. Ice creams drawn from a continuous freezer at the same temperature as from a batch freezer were smoother due to finer incorporation of air. Martin, Nelson, and Caulfield (88) collected 318 commercial samples of ice cream. A positive phosphatase test appeared to be correlated with flavor, texture, body, and color in the samples. On the average an increase in butterfat was accompanied by an increase in score (total score minus bacterial score). Samples weighing 4.50 to 5.49 pounds per

gallon, with few exceptions, scored highest in body and texture. These weights correspond to 102 and 66 per cent overrun, respectively. Over and under these amounts of overrun the trend of the body and texture scores was downward. Specific defects in the samples were not given by the authors.

Frandsen, Rovner, and Luithly (53) found corn syrup improved body and texture when it replaced 30 per cent of the sugar ordinarily used. Davis (40) found that decreasing sugar below normal caused unsatisfactory texture while increasing it greatly improved texture. Ruehe (119) stated in 1919 that glucose as a sweetener caused a coarse grained ice cream. Lucas, Matsui, and Mook (75) found 15 to 17 per cent of sugar strengthened body of ice cream. Tracy (136) claimed in 1936 that corn sugar caused smoother texture and softer body in ice creams. Corbett and Tracy (22) the same year reported that dextrose caused a heavier bodied ice cream than sucrose when frozen in a continuous freezer but that the body was not objectionable. Corbett and Tracy (23) in 1939 stated that replacement of 25 per cent of the sucrose in ice cream with dextrose had little, if any, effect on body and texture. Dahlberg and Penczek (27) found a new type of liquid corn syrup improved body and texture slightly, and the syrup, new type dry corn sugar, and corn sugar eliminated development of sucrose crystallization. Tracy (138) found that when "Sweetose," a high conversion corn syrup, was used to replace 25 to 33⅓ per cent of the sucrose in ice cream mixes improved body resulted.

Tracy (133, 134) in 1923 stated that superheated condensed milk caused ice creams containing it to be heavier in body and smoother in texture. In these respects it was deemed superior, but inferior in flavor. The Kansas Experiment Station (66) announced in 1930 that ice creams made with superheated condensed milk and homogenized without gelatin were coarse and rough. On the whole, it was stated, superheating was detrimental to high quality. Lucas and Jensen (78) found that ice creams with 50 per cent or more of the fat content coming from butter tended slightly towards coarseness. Aging 48 hours improved the body and texture. Reichart and Corley (107) found that frozen condensed milk in ice cream caused iciness and coarseness when the ice cream had been held two weeks in the hardening room. Under practical conditions, they state the defect would be hardly noticeable. Iverson (64) stated that serum solids, used correctly, improved body of ice cream.

Smith (125) stored quart and pint packages of vanilla, chocolate, strawberry, and maple-walnut ice creams for 16 to 24 weeks at – 6° to – 20° F. and then scored them at intervals. Body and texture were not changed by storage. Except for chocolate, ice creams stored in unlined packages developed an icy surface film in three to four months. Tracy, Ruehe, Tuckey, and Ramsey (141) fed three groups of cows identically, except that the protein

came from different sources. Mixes were made from cream from each of the three groups. Feed had no effect on whipping ability. Ice cream from each group made in the continuous freezer was smoother than that made in the batch freezer but, at low overrun, was more gummy. Excessive amounts of gelatin in mixes frozen in the continuous freezer favored gummy texture and made overrun incorporation difficult but not so much as with the batch freezer. High serum solids favored gummy texture. A 10:10:15:0.3 mix was much better when made in the continuous freezer than one with 12 or 16 per cent of serum solids. Maack and Tracy (84) found that oat flour improved body and texture, as did Mueller and Mack (95).

Sandiness. Bothell (10) in 1920 observed that sandiness of ice cream was due to lactose crystallization. In 1920 and 1921 Lucas (79, 80, 81, 82) reported sandiness in ice cream was due to crystallization of the lactose, that the critical serum solids content appeared to be 10 per cent, and that combinations of gums and gelatin tended to prevent it (later proved erroneous). In 1921 Zoller and Williams (155) prepared sandy ice creams and removed the crystals by centrifuging. Microscopic examination showed them to be lactose crystals of the alpha form. Solubility tests confirmed the conclusion.

In 1922, Williams (154) ascribed sandiness in ice cream as due to: 1, sandy concentrated milk; 2, excessive serum solids and therefore excessive lactose in the mix; and 3, hardening room temperature fluctuation. In 1922, also, Palmer and Dahle (104) studied lactose in solution at 0° F. At 32° F. its solubility was approximately 10.5 per cent. Starting with 15 to 17 per cent solutions it was possible to keep 12.5 to 13.5 per cent in solution, even when held 14 days at 0° F. Neither stabilizers nor acids had any effect on its solubility. Zero temperature delayed crystal growth more than temperatures of 15 to 25° F. In 1921 the Oklahoma Experiment Station (103) announced that inclusion of more than 12 per cent serum solids in the mix might result in sandy ice cream. Skimmilk powder and sweetened condensed milk were used to increase the total solids to 38 and 40 per cent without causing sandiness.

In 1922 Des Jardins (43) listed four causes of sandiness in ice cream: 1, use of products containing undissolved lactose; 2, use of products high in acidity; 3, mixes high in serum solids; and 4, heat shocking. He recommended avoidance of these conditions, and proper pasteurization and aging to dissolve any crystallized lactose. In 1923 (Ambrose (2) stated that mixes high in milk-solids-not-fat developed sandiness. The defect was frequent with milk-solids-not-fat at 14 to 18 per cent but developed in only two cases when less than 14 per cent. It appeared after a two to three weeks storage period and most frequently after three weeks.

Whittaker (151) set 12 per cent as the upper limit for milk-solids-not-fat in order to prevent sandiness. The longer the ice cream was in the freezer and the lower the temperature the sooner lactose crystallized. Rapid hard-

ening retarded crystallization and conversion of beta to alpha lactose. Conditions remaining the same, bulk ice cream developed sandiness quicker than packaged. Fluctuating temperatures in the ice cream cabinet hastened development of sandiness but mechanical shock proved only an insignificant factor. Nuclei caused more rapid crystallization. Sandiness developed much later in mixes pasteurized at 175° F. than when pasteurized at 145° F. or 160° F. Homogenization temperatures had little effect but presence of nut meats facilitated crystallization, due at least in part to their water absorptive power. Increase in fat clumping materially retarded crystallization.

Webb and Williams (149), to avoid sandiness, manufactured low lactose concentrated skimmilk for ice cream use by removing 65 per cent of the lactose without dispersing the proteins. To prepare it, 5.9 pounds of sucrose was added to 100 pounds of fresh skimmilk, the mixture warmed to and held at 63° C. for 10 minutes, evaporated in a vacuum pan to 70 per cent total solids, cooled to 25° C., held at 10° C. for 20 hours, after which the crystallized lactose was removed either by centrifuge or filter press. When used to supply 11 to 13 per cent serum solids in mixes no sandiness occurred and texture was improved. Sommer (127) stated in 1936 that, mix formulae remaining the same, serum solids in milk are higher in the winter because milk is higher in solids-not-fat in winter than in the summer. He mentioned this as a reason, as well as slow turnover, for sandiness being more frequent in winter than summer.

Gibson (54) used several milk concentrates for prevention of sandiness. "Pro-lac" powder caused a sticky, spongy body; "High Solids" above 6 per cent a dry, powdery body; spray and vacuum roll powders the same; and atmospheric roll powder a dry, rough body. Excessive serum solids caused sandiness more quickly. "High Solids" retarded the tendency. Pasteurization at 160° to 175° F. delayed sandiness no longer than pasteurization at 145° F. Homogenization had no effect. Keith, Rink, and Weaver (67) found that addition of sodium bicarbonate and sodium citrate to the mix decreased viscosity, clumping of fat globules, and titratable acidity. Calcium carbonate had the opposite effect. In the last case all samples of ice cream, including those containing nuts, developed sandiness. With sodium citrate sandiness was hastened with dry nuts and slightly hastened with nuts treated with hot simple syrup.

Erb (47) in 1931 attempted to control sandiness in ice creams containing 17 per cent of serum solids by replacing sucrose with equal parts of a mixture of 20 per cent maltose syrup, 25 per cent of dextrose, and 25 per cent of invert sugar. No variation prevented lactose crystallization, although by holding water content constant and using 12, 15, 18, and 20 per cents of sucrose with proportional decreases in fat, crystallization was retarded. In aqueous solutions of lactose the presence of no other sugar affected crystalli-

zation. In 1931 and 1933 Reid and Powell (115, 116) named three conditions responsible for sandiness: excess of serum solids, presence of nut meats, and heat shocking. Alkali and acid hastened final solubility of lactose but hastened crystallization once it had started. Grape nuts did not act in hastening sandiness as did ordinary nuts. The influence of the latter was lessened by boiling the meats before use in water, sugaring and autoclaving them, or by gelatinizing them. The first two processes were not recommended for practical use. Iverson (64) corroborated in 1937 the findings of other investigators that excessive serum solids in the mix would cause sandiness. Corbett and Tracy (23) in 1939 stated that replacement of 25 per cent of the sucrose in mixes with dextrose delayed slightly development of sandiness in high solids mixes. Dahlberg and Penczek (27) in 1940 stated that new type liquid corn syrup, new type dry corn sugar, and corn sugar had no great effect on development of sandiness.

Tracy and Corbett (142, 143) in 1939 described the preparation and use of a low lactose milk for replacing a portion of the serum solids in mixes for prevention of sandiness. They found its use not only effective in this respect but found it improved body. The authors listed several recipes for its use. Decker, Arbuckle, and Reid (41) in 1939 examined sandy material under a petrographic microscope and found alpha hydrate and beta anhydride lactose crystals with the former predominating. The former crystallized sooner than the latter. They found that in high serum solids ice cream held for 12 months at – 10° F. sandiness did not develop. The same ice cream held a time in a cabinet at 6° to 10° F. and subsequently at – 10° F. for five months showed pronounced sandiness, an illustration of the effect of varying temperatures.

Melting resistance and hardness. Stebnitz (129) stated that in melting ice cream should give up its air quite readily and change to a rich creamy liquid and that its melting behavior is influenced by amount and kind of stabilizer and the heat treatment given the mix ingredients. Holdaway and Reynolds (60) in 1916, using in one gallon of basal mix: 1, one ounce of gelatin; 2, 0.4 ounce of gelatin; 3, 0.4 ounce of cooked corn starch; 4, 0.4 ounce of gum tragacanth; and 5, control sample, found their hardness and melting resistance to be in the order named. When 8, 19, and 30 per cent cream was used in the mixes the score was the same except that 4 and 5 exchanged places. In hardness, ice creams made without filler from 30 per cent cream were firmest and from 8 and 19 per cent cream equally firm. Melting resistance increased with increase in fat content especially between 8 and 19 per cent. Those containing gelatin up to one ounce per gallon were hardest and most heat resistant. Gum tragacanth stabilized ice cream was smooth and soft. With this stabilizer an increase in fat decreased hardness and resistance to heat. Corn starch compared favorably with gelatin but caused a granular ice cream.

Manhart (86) used in ice cream mixes three grades of gelatin of poor, good, and very good quality at the rate of 0.6 per cent. The better the grade of gelatin the greater was the resistance to heat of the ice cream in which it was used. Ice creams containing a poor grade were more resistant to heat than those containing none. The correlation between gelatin and resistance was significant.

Ambrose (2) stated that increase in serum solids and fat increased resistance to melting. Tracy (133) found that the use of superheated condensed milk in ice cream increased resistance to heat. Lucas, Matsui, and Mook (75) found in 1933 that use of in excess of 15 per cent of sucrose, because of melting point lowering, caused ice creams to have poor standing up qualities.

Caulfield (16) in 1930 found the same to be true with several commercial chocolate syrups. Dahlberg and Penczek (27) noted that replacing more than 25 per cent of the sucrose with corn sugar reduced the melting point and softened the ice cream. Corbett and Tracy (22) also found this to be true.

Mueller (98) observed that when ice creams melt down slowly the melted portion has a curdled appearance. Ice creams showing this tendency had been aged at a high initial temperature. The author believed this to be an important factor in such cases. Foskett and Mack (51) have stated that plastic cream in ice cream mixes affected melt down adversely. Lucas and Jensen (79) found that butter supplying 50 per cent or more of the fat in ice cream lowered melting resistance; milk powder versus condensed skimmilk had no effect; nor did prolonged aging. Reichart and Cooley (107) noted that ice creams made from frozen condensed skimmilk melted down twice as fast as when made from fresh condensed skimmilk. Mueller and Mack (95) found oat flour to increase melting resistance. Crowe and Winn (26) and Crowe, Deane, and Winn (25) observed that ice creams made with fresh superheated condensed skimmilk melted more slowly than those made either with fresh plain condensed or sweetened condensed skimmilk, but, when these were stored from two to three months, exactly opposite results were obtained, storage, it was believed, causing the change. The differences, however, were not great. Superheated condensed skimmilk, either fresh or frozen, lent to ice cream more resistance to heat. It produced less foam on melting. Fresh sweetened condensed skimmilk produced most foam, but, when stored one month before use, plain condensed skimmilk produced most foam. Ice cream made from plain condensed skimmilk melted down smoothly while that made from stored frozen superheated skimmilk melted often with a curdy appearance, the sides frequently falling off in chunks. Ice cream from fresh sweetened condensed skimmilk always melted smoothly and evenly but if stored the melted portion often had a flaky or curdy appearance.

Shrinkage. Kohler (68, 69) ascribed shrinkage as due to six causes:

stability of the milk-solids-not-fat, especially those from condensed skimmilk, processing, freezing, hardening, transportation, and storage. He considered the first as most important and suggested its regulation by addition of calcium and sodium phosphates and citrates. High temperature pasteurization, high pressure homogenization, high speed continuous freezing, and excessively low hardening temperatures, he held, increased instability of serum solids and increased shrinkage. Shrinkage caused by high pressure homogenization, poor freezing, and faulty transportation was not severe. High overrun or type of package, paper or metal, were not causes of shrinkage. Use of low Bloom gelatin, he found, might introduce additional calcium. If used, he advised that a small amount of sodium bicarbonate be added at the start of pasteurization, followed by an equal or slightly smaller amount of disodium phosphate when the temperature reached 100 to 120° F. Lucas and Roberts (83) called attention to the probability of 10-per-cent-fat ice creams, containing less than 10 per cent serum solids, sinking in the container. Cole (20) stated that ice creams frozen at low and shipped to high altitudes may expand and under reverse conditions the opposite may happen. Shrinkage having occurred, change in pressure did not restore the volume. Under these conditions the harder the ice cream the less the shrinkage.

Soggy, sticky, dry, and crumbly body defects. Reid and Painter (109) observed in 1933 that chocolate ice cream containing in excess of 17 per cent sugar had a soggy, sticky body and texture. Egg powder in chocolate ice cream produced smooth texture. Reid (110) noted that when ice cream was served at 20° F. or higher it was soft and the body tended to be gummy and sticky. Corbett and Tracy (23) found that when ice creams containing 25 per cent dextrose were frozen in a continuous freezer the body was slightly sticky unless gelatin was reduced by one fourth. Dipping losses were slightly increased. Lowering the dipping temperature one degree did not remedy the situation. Heyl and Tracy (59) reported in 1940 that overfreezing on a continuous freezer or drawing ice cream at too low temperatures, when enough gelatin has been added to permit drawing the ice cream at higher temperatures, resulted in gummy, sticky body. They advocated the use of such quantity of gelatin as would produce good body under the conditions peculiar to the plant. Iverson (64) found excessive serum solids to cause sogginess.

Hening and Dahlberg (58) reported in 1923 that addition of lactic or citric acid or the natural development of lactic acid to 0.3 or 0.4 per cent in mixes before pasteurization and homogenization caused hard crumbly body. Neutralization of the acid from 0.3 to 0.4 per cent in mixes before pasteurization and homogenization caused hard crumbly body. Neutralization of the acid from 0.3 per cent with sodium bicarbonate gave a better flavor than when sodium or calcium hydroxides were used. Mack (85) in 1934 asserted that high solids in the mix caused excessive viscosity and

crumbly body. It was usually caused by the substitution of butter or frozen or plastic cream in part or wholly for sweet cream. Increasing sugar content to 16 or 17 per cent helped to remedy the defect. If this degree proved too sweet he found substitution of 3 to 4 per cent of sucrose with corn sugar helpful. Mixes containing 18 to 20 per cent fat were apt to produce crumbly ice cream. For these he recommended three stage homogenization: 2000, 500, and 150 pounds pressure for 18 per cent fat mix; and, 1500, 500, and 150 pounds for 20 per cent fat mix. Corbett (24) made ice cream using 3.5 to 4.5 per cent low lactose serum solids with 9.5 to 8.5 per cent ordinary serum solids and found the combination satisfactory. More than these amounts caused dry, crumbly body. The difficulty was overcome by substituting dextrose for one-fourth of the sucrose.

Buttery, churned defects. Mortensen (93) stated in 1915 that pasteurization of the mix reduced viscosity, thereby lowering resistance to churning. As remedies he suggested holding the mix after pasteurization for 24 hours within a few degrees of freezing or homogenization. Baer (6) stated in 1918 that either centrifugal or steam emulsification made churning in the freezer more difficult. Ambrose (2) found that the use of 6 per cent milk-solids-not-fat increased the tendency of a mix to churn in the freezer.

Ice and sherbet defects. Dahlberg (28) in 1926 recommended replacement of 20 to 25 per cent of sucrose in sherbets with corn sugar to prevent crystallization of sucrose. He recommended 7 per cent corn sugar with 25 per cent sucrose as the best combination, and 0.2 per cent agar-agar with 0.4 per cent gum tragacanth or high grade India gum as a stabilizer. The author, with Penczek (27), later declared corn sugar or syrup essential for ices and sherbets. Smallfield (123) prevented crust formation on ices and sherbets by using 8 per cent honey with 22 per cent of sucrose.

Tuckey (146) stated in 1932 that two factors controlled hardness in ices and sherbets, sugar content and overrun, the former being the more important. Gums used alone caused crumbly body and excessive hardness. Gelatin caused excessive overrun but not crumbly body. Edman and Tracy (45) found that the new type of high conversion corn syrup, "Sweetose," containing increased dextrose and reduced dextrin, remained soluble in water when stored at – 15° F. It proved to be of decided advantage in preventing surface crustation on water ices. Tracy (138) improved body and texture of sherbets and ices by using "Sweetose" to replace 33 to 50 per cent of the sucrose normally used. Reid (111) stated in 1937 that sherbets served at 14° F. or higher were soggy. The Nebraska Experiment Station (101) reported in 1928 that sealing sherbet containers prevented sugar crustation at the surface. Parchment covers helped. Crustation was retarded materially by replacing a portion of the sucrose with invert or corn sugar. Gums proved unsatisfactory as stabilizers because of flavor.

Miscellaneous. Dahle and Josephson (36, 37) found that oat flour im-

proved body and texture. Martin and Caulfield (87) found that the use of 0.5 per cent of egg yolk in the mix did not affect body and texture adversely. Mueller and Button (96) found that 1 per cent dry egg yolk or dry whole egg improved texture while 1 per cent dry egg albumin injured texture. The improvement caused by dry egg yolk and dry whole egg was more noticeable in mixes of low solids content.

DEFECTS IN COLOR

Smith and Tracy (124) stated that consumers prefer a medium yellow color in ice cream. Ayres, Johnson, and Williams (3) found in 1918 that some grades of corn sugar imparted a yellow color. (Corn sugar in 1917–18 possessed a slight yellow color.) Ruehe (120) published that heating sucrose in the inversion process longer than 35 minutes darkened it, imparting to the syrup and the mix in which it was used an undesirable color. Tracy (136) and Corbett and Tracy (22) in 1936 found that corn sugar lowered color very slightly. Joslyn and Cole (65) found discolored frozen fruits affected adversely the color of ice cream.

Maybee (90) declared in 1939 that the finer cocoa is ground the deeper the color. Dahlberg (29) investigated in 1923 a greenish black discoloration in chocolate ice cream and found it to be due to chemical reaction between the tannins in cocoa or chocolate and exposed iron or rust spots on the containers. The discoloration appeared usually in the hardening room and occasionally in 1 to 10 days in the dealer's cabinet. The discolored ice cream tasted fishy. Alkaline, not acid, cocoa caused the difficulty. As remedies he suggested use of paper can liners, well-tinned containers, or, cocoa and chocolate free of tannins and alkali. Three out of eight samples examined contained tannins capable of entering into the chemical reaction.

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ABSTRACTS OF LITERATURE

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United States Department of Agriculture

ABSTRACTS OF LITERATURE

ADVANCE ABSTRACTS OF REPORTS TO APPEAR IN THE JOURNAL OF DAIRY SCIENCE

197. Effect of Proteolysis on Lipase Induced Rancidity in Cheddar Cheese. I. HLYNKA, E. G. HOOD AND C. A. GIBSON, Central Experimental Farm, Ottawa, Canada.

A study of the effect of proteolytic enzymes on added lipase in Cheddar cheese in relation to rancid and other flavor defects is reported. Two series of cheese as nearly identical as possible except for the variable under consideration were made. Series A contained 2.5–5.0 gms. commercial lipase per 1000 lbs. milk and was coagulated with 2–3¼ oz. rennet per 1000 lbs. Series B contained the same amount of added lipase, but a higher amount of rennet and pepsin combined or pepsin alone. The results show that cheese of the B series had a higher flavor score than corresponding cheese of series A. It is concluded that proteolytic enzymes prevent the development of rancid flavor in Cheddar cheese by the inactivation of lipase through proteolysis. This is suggested as an additional function of the proteolytic enzymes of rennet. Authors' Abstract.

198. The pH Values of the Ingesta of the Rumen of Slaughtered Animals. T. M. OLSON, Dept. Dairy Husbandry, South Dakota State College.

A total of 473 samples of rumen ingesta were taken from animals slaughtered at two of the leading slaughtering plants in the state.

These samples were taken to the college laboratory, where the pH was determined on the Coleman's electric potentiometer. The samples were then allowed to stand in the laboratory at room temperatures for varying periods of time up to 235 hours. During this period of time pH determinations were made, at 22, 30, 45, 70, 95, 120, 150, 168, and 235 hour intervals after the samples had been taken.

The pH of the fresh samples average 6.89. The pH at the end of the holding periods were, 7.00 at 22 hours, 6.97 at 30 hours, 7.02 at 45 hours, 7.22 at 70 hours, 7.54 at 95 hours, 7.27 at 120 hours, 7.72 at 150 hours, 7.49 at 168 hours, 7.96 at 235 hours. Not all samples were tested at each period.

These trials indicated a definite increase in alkalinity up to 235 hours in samples which were allowed to stand at room temperatures. No explanation is offered. Author's Abstract.

199. The Feeding Value of Grass Silage in the Ration for Dairy Cows. O. L. LEPARD[1] AND E. S. SAVAGE, Department of Animal Husbandry, Cornell University, Ithaca, N. Y.

[1] Now Associate in Dairy Husbandry at the New Jersey Experiment Station, Sussex, New Jersey.

Various combinations of molasses silage (grass, clover and alfalfa), corn silage and dry hay were fed to three groups of cows over a fifteen week period. There was no significant difference in the production of the animals in the various groups, providing the total nutrient intake remained constant.

Molasses silage (grass, clover and alfalfa) was fed as the only roughage to eleven milking cows for twelve weeks. They maintained normal milk production and body weight. However, many of the animals were unable to consume the normal roughage nutrient intake on this diet. The decrease in nutrient consumption was compensated for by an increase in the amount of grain.

In a ten-week single reversal feeding trial, phosphoric acid silage (grass, clover and alfalfa) was found to be equal in feeding value for milk production and maintenance of body weight to molasses silage (grass, clover and alfalfa) when the grass silages were used to replace corn silage in a normal ration of corn silage, mixed hay and grain.

In a twelve-week single reversal feeding trial, phosphoric acid silage (grass, clover and alfalfa) was found equal in feeding value for milk production and maintenance of body weight to molasses silage (grass, clover and alfalfa) when the grass silages were used to replace mixed hay in a normal ration of corn silage, mixed hay and grain. Authors' Abstract.

200. Storage of Dairy Bull Spermatozoa. ERIC W. SWANSON AND H. A. HERMAN, Department of Dairy Husbandry, University of Missouri.

A study was made of the storage capacity of semen from 10 bulls in service of the University of Missouri herd. Refrigerator temperatures of 40° F. were found satisfactory for storage purposes. The ability to survive under storage conditions was indicated to be an inherent quality of the spermatozoa and good quality semen survived longer when stored undiluted than when diluted with any of the diluents studied. Of the various dilutor materials used, the egg-yolk buffer solution proposed by the Wisconsin Station was the only one giving beneficial results. Glucose solutions and Milovanov's SGG_2 dilutor were of no value in prolonging life of the spermatozoa and for most part were harmful.

Thirty inseminations with semen stored 24 to 198 hours and shipped 40 to 400 miles resulted in 15 pregnancies. One calf was produced with a 198-hour-old sample. Authors' Abstract.

201. Utilization and Excretion of Ascorbic Acid by the Dairy Cow. C. A. KNIGHT, R. A. DUTCHER, N. B. GUERRANT AND S. I. BECHDEL, Pennsylvania State College.

Ascorbic acid (vitamin C) was administered to Holstein cows (a) mixed

with a small amount of corn silage, (b) in gelatin capsules, (c) in aqueous solution, (d) by subcutaneous injection and (e) by intravenous injection. Massive doses, ranging from 1,000,000 to 3,000,000 International units per day of ascorbic acid were administered.

By non-injection methods, it was impossible to cause an increase in the ascorbic acid content of milk or blood and there was but a slight increase in the concentration of ascorbic acid in the urine.

It was only by injection methods that a significant increase in the ascorbic acid concentrations of blood, milk and urine could be demonstrated. The greatest increase in milk ascorbic acid, brought about by intravenous injection, was from 20 mg. per liter to 30 mg. per liter.

By means of a rumen fistula it was found that ascorbic acid is destroyed very rapidly in the rumen, which furnished an explanation for the failure to cause an increase of ascorbic acid in blood, milk and urine when ascorbic acid is fed in massive doses.

Simultaneous application of indophenol titrations and the furfuraldehyde method showed that ascorbic acid is present in the reduced form in fresh milk and fresh urine. Evidence is presented indicating that the dairy cow is able to synthesize ascorbic acid.

These studies are being continued with the hope (a) of explaining the mechanism of ascorbic acid destruction in the rumen, and (b) of obtaining further evidence relative to the synthesis of ascorbic acid by the dairy cow.

Authors' Abstract.

BOOK REVIEWS

202. Fundamentals of Bacteriology. MARTIN FROBISHER, JR. W. B. Saunders Co., Philadelphia, Pa. 1940. Second Edition, 653 pages, 326 illustrations. $4.00.

This book is intended as a text for the beginning student in bacteriology. Section I provides a brief introduction in which the origin and discovery of bacteria are discussed. This is followed by chapters on morphology and structure, relationships to other micro-organisms and enzymes, nutrition and metabolism, effects of environment upon bacteria, principles of sterilization and disinfection, and immunology.

Section II is introduced by a brief treatment of bacterial nomenclature and classification of bacteria. In this section, the most important bacteria are grouped, for the most part according to tribes and families. The morphology, activities, and industrial or medical significance of individual and related organisms are briefly discussed. Section III contains one chapter on industrial aspects of bacteriology, eight chapters dealing primarily with medical bacteriology, and one chapter each on viruses and pathogenic protozoa.

The method of presentation provides a beginning text that is well written, interesting, and informative. The book is remarkably well illustrated which aids greatly in the effectiveness of discussions. P.R.E.

203. What Are the Vitamins. WALTER H. EDDY, Ph.D. 254 pp., illustrated. Reinhold Publishing Corporation, New York, N. Y. Jan. 1941. $2.50.

From the voluminous literature concerning the vitamins the author has attempted to select, review and coordinate "what seems to him pertinent and reliable information" in answer to the many questions of a vitamin-conscious public. In this he has succeeded remarkably well.

One is delighted with the brief, concise style in which the subject matter is presented. The first two chapters discuss the nature of these compounds we call vitamins and what they do. Of particular interest is the discussion of the part played by the vitamins in cellular respiration and tissue metabolism. Following this discussion separate chapters are devoted to vitamin A, B_1 (Thiamine), Riboflavin (B_2 or B), Nicotinic Acid (P–P), B_6, other members of the B complex, C, P, D, E and K.

In Appendix A the formulas and chemical structures of the vitamins which have been isolated and identified are presented. A useful table of the vitamin values of foodstuffs is presented in Appendix B. T.S.S.

BACTERIOLOGY

204. Effect of Smoke on Bacteria in the Air. C. C. TWORT AND A. H. BAKER. Lancet, *239:* (6115) 587–589. Nov., 1940.

Smokes produced by smoldering six organic substances were lethal to the bacteria in atomized normal saliva and to atomized cultures of *Escherichia coli* a strain of gram positive cocci, and *Salmonella enteriditis.* Cardboard and incense were the most satisfactory materials used for producing lethal smoke, incense smoke showing some evidence of lethal effect after a half hour's exposure in concentrations as low as 1 gram in 3,000 cu. m. of air. Magnesium oxide and ammonium chloride smokes in a concentration of 1 gram in 10 cu. m. of air had no apparent lethal effect under the conditions of the experiment. J.F.C.

205. Studies on the Lactase of *Escherichia coli.* H. P. KNOPFMACHER AND A. J. SALLE. J. Gen. Physiol., *24:* 377–397. 1941.

A "lactase solution" was prepared from *Escherichia coli.* The mechanism of its action has been studied and changes in the rate of hydrolysis under various conditions investigated.

The hydrolysis of lactose by the enzyme approximates the course of reaction of the integrated Michaelis-Menten-equation. One molecule of enzyme combines with one molecule of substrate.

E. coli lactase is readily inactivated at pH 5.0, and its optimal activity at 36° C. is reached between pH 7.0 and pH 7.5.

The optimal temperature for its action was found to be 46° C. when determinations were carried out after an incubation period of 30 minutes.

The enzyme is inactivated by potassium cyanide, sodium sulfide, and cysteine, and irreversibly inactivated by mercuric chloride, silver nitrate and iodine. After inactivation with copper sulfate partial reactivation is possible, while the slight inhibition brought about by hydrogen peroxide is completely reversible.

The possible structure of the active groups of *E. coli* is discussed.

D.E.

206. Comments on the Microbiology of Spoilage in Canned Foods. E. J. CAMERON AND J. R. ESTY. Food Res., *5:* 6, 549. Nov.-Dec., 1940.

The authors briefly summarize information relative to bacterial spoilage of canned foods and attempt a classification of spoilage types based on the acidity of the medium. Milk is placed in "Group 1—Low Acid—pH 5 and Higher." The foods in this group are subject to spoilage by the thermophyllic organisms of which *B. stearothermophilus, C. thermosaccharolyticum, C. nigrificans* and *B. thermoacidurans* are examples; and by the misophilic group of putrefactive anaerobes. Of less importance are the so-called aerobic spore formers. F.J.D.

BUTTER

207. Butter Grading and Its Relation to Quality Improvement. B. M. OMMODT. Nat. Butter and Cheese J., *32:* 1, 20. Jan., 1941.

Impartial, accurate butter grades indicate the success or failure of the producer and manufacturer. Such information can be used by fieldmen to guide their improvement programs. Close correlation of cream grades with butter grades requires careful grading of raw material. Cream for U. S. 93 score butter should be fresh and have a fine, sweet, clean flavor; acidity of individual cans should be not more than 0.20 per cent. Cream for 92 score butter should be fresh and free from objectionable flavor; acidity development should preferably not exceed 0.30 per cent. Slight cuts on workmanship do not reduce U. S. grades but serve as warnings to overcome the faults before they become serious. W.V.P.

CHEESE

208. Cheese in Consumer-size Packages. H. L. WILSON. Nat. Butter and Cheese J., *32:* 1, 64. Jan., 1941.

Cheese to be canned must be of excellent quality. Such cheese can be made by care in selection of milk, flash pasteurization of milk by heating

to 160–165° F. or to 140–143° F. for 30 minutes by the holding method, use of minimum amounts of starter, regular ripening periods, development of acid in whey to only 0.15 per cent at dipping 2¼ hours after setting and to only 0.5 per cent acid 4½ hours after setting. Cheese properly made will have 36 to 38 per cent moisture. High quality cheese in cans can be cured at 50 to 60° F. without shrinkage. Add 3½ cents per pound to the cost of cheese in 8 oz. cellophane-wrapped prints in 5 lb. tin cans and shipping cartons and 2½ cents to the cost if packed in 20 lb. tins. Wrapped prints will keep for 7–10 days without molding or drying after the can is opened. Sliced cheese can be packed in the cans for curing and merchandising. The cure of the cheese is not affected by the can. W.V.P.

209. Effect of Certain Bacteria on Flavor of Cheese Made from Pasteurized Milk. W. C. HARRIS, B. W. HAMMER, AND C. B. LANE. Nat. Butter and Cheese J., *32:* 1, 10. Jan., 1941.

This paper was printed in full in the JOURNAL OF DAIRY SCIENCE, **23**: 701. 1940. W.V.P.

CHEMISTRY

210. The Preparation of a Casein Hydrolysate for the Study of the Relationship between Choline and Homocystine. A. D. WELCH. J. Biol. Chem., *137:* 173. 1941.

A method is described for the preparation of a hydriodic acid hydrolysate of casein which is grossly deficient in trytophane, methionine and growth-promoting derivatives of homocysteine. The hydrolysate serves as a relatively inexpensive substitute for mixtures of purified amino acids for the study of the relationship between choline and homocysteine. V.C.S.

211. Analysis of Proteins. 12. Dephosphocaseose or Depocaseose. T. J. REW MACARA AND R. H. A. PLIMMER. Biochem. J., *34:* 1431. 1940.

The action of 1 per cent sodium hydroxide on casein may be summarized as follows:

(a) Hydrolysis of the ester linkages by which the phosphoric acid is believed to be bound.

(b) Hydrolysis of approximately half the dicarboxylic acid amide groups during 24 hours.

(c) Some change as a result of which the complex system of casein is separated into two main components, depocasein and depocaseose which from chemical data appear to be of the same molecular size between 75,000 and 100,000, and they exhibit small yet significant differences in amino

acid composition. It is believed that the difference in properties, such as solubility between the metaprotein and proteose are dependent on the amino acid composition and not on molecular size.

(d) It appears probable from molecular weight and other data that dilute sodium hydroxide does not attack peptide linkages to any great extent, if at all. V.C.S.

212. **Determination of Carotene in Plant Material. Dicalcium Phosphate as an Adsorbent.** L. A. Moore. Ind. Engr. Chem., Analyt. Ed., *12:* 12, 726–29. Dec., 1940.

An improved method for the determination of carotene in stored hay, silage, and other plant material and feces is reported. Dicalcium phosphate is used to adsorb non-carotene pigments from the petroleum ether extract used in the Willstätter-Stoll method for carotene determination. Dicalcium phosphate was found to be an adsorbent which would remove the noncarotene pigments, its use required no special precautions nor did it change on standing in the laboratory. The method consists essentially of extraction with alcohol, extraction of the alcoholic extract with petroleum ether, removal of alcohol from the petroleum ether, and passing the extract through a Tswett column of dicalcium phosphate. The value obtained is probably for pure carotene. The results indicate that the Willstätter-Stoll method or its modifications for the determination of carotene are not accurate for plant material which has been subjected to storage or to the action of the digestive tract. B.H.W.

DISEASE

213. ***Brucella melitensis* in Cow's Milk.** F. W. Duke. Lancet, *239:* (6113) 517. Oct., 1940.

A *Brucella* culture obtained aerobically in primary culture from the mixed milk of a herd of 76 cows was identified as *Br. melitensis.* Three cows in the herd provided samples from which *Br. melitensis* was recovered. At no time during the last 14 years had there been any goats on the farm. J.F.C.

FEEDS AND FEEDING

214. **Rumen Synthesis of the Vitamin B Complex.** M. I. Wegner, A. N. Booth, C. A. Elvehjem, and E. B. Hart. Proc. Soc. Exp. Biol. and Med., *45:* 769. 1940.

The ability of a heifer calf with a rumen fistula to synthesize significant amounts of thiamin, riboflavin, nicotinic acid, pyridoxine, pantothenic acid, and biotin when fed a ration very low in these compounds was demonstrated. Rumen samples taken 6 hours after the feeding of 200 mg. of thiamin in the

calf ration and assayed for the vitamin B complex indicated that there is little, if any, destruction of thiamin in the rumen. At the same time there was an apparent stimulation of the synthesis of the other factors assayed for, with the exception of nicotinic acid, when thiamin was added to the synthetic ration. R.P.R.

215. **Relation of Dietary Fat to Riboflavin Requirement of Growing Rats.** G. J. MANNERING, M. A. LIPTON, AND C. A. ELVEHJEM. Proc. Soc. Exp. Biol. and Med., *46:* 100. 1941.

It was demonstrated that increasing the fat level in a riboflavin-low ration had a corresponding deleterious effect on the growth of young rats and that the administration of adequate amounts of riboflavin completely corrected this deficiency. The authors were of the opinion that from a number of possible explanations for the antagonistic effect of fat on riboflavin, two deserved special consideration. In the first place, increasing the level of fat in the diet might alter the intestinal flora so that less than normal bacterial synthesis or more than normal bacterial destruction of riboflavin occurred. Secondly, riboflavin might be directly concerned with fat metabolism of phosphorylation. R.P.R.

216. **Einsäuerungsversuche mit Silomais und Verdauungsversuche mit verschieden hergestelltem Maisgarfütter zu Schafen (Ensiling Experiments with Silage Corn and Digestion Experiments with Variously Prepared Corn Silage Fed to Sheep.)** K. SCHARRER, AND R. SCHREIBER. Biedermann's Zentralblatt, Abteilung B., *12:* 46–76. 1940.

Ensiling experiments were conducted with mature corn (maize) with and without the addition of preservatives. Digestibility of the product was determined by digestion experiments with sheep. The preservatives used were: sugar—0.75 kilo per 100 kilos of corn, "Biosil"—0.25 kilo per 100 of corn—0.50 kilo per 100.

No significant differences were noted in the proximate analyses of the several silages. Acid distillation by the method of Lepper-Flieg gave a high content of lactic acid, but little or no butyric acid. The silage to which preservative had been added had a lesser proportion of total organic acid as lactic acid (75 per cent) than the silage without preservative had (83 per cent). pH of all four silages was below 4.0 which is recognized as very good.

The silage was keenly relished by sheep. Digestibility was as follows: dry matter, approx. 68.6; organic matter, 71.2; crude protein, approx. 51.0; fat 84.3; n-free extract, approx. 76.0. Digestibility of crude fiber varied from 50.4 to 72.9.

Digestible true protein (average of 8 trials) was 0.45 per cent in the

fresh substance and 2.54 per cent on a dry basis. Similarly starch values were 9.54 kg. and 53.89 kg. These results are in accord with those reported by Fingerling. J.G.A.

217. Untersuchungen über die zweckmassigste Konservierungsmethode der Luzerne (Studies of Methods Suitable for Preserving Alfalfa). E. BRUMMER. Biedermann's Zentralblatt, Abteilung B., Tierernährung *12:* 77–128. 1940.

An extensive investigation planned to establish through analyses and feeding experiments which is most economical and practicable, artificial drying of alfalfa or ensiling of it. Lots of hay from the same field were dried artificially, dried on wire, dried on tripods (Dreibockreuter), and ensiled with and without preservatives. The preservatives used were "Defu" solution and sugar.

Contrary to prevailing experience, slow drying on wire or tripods at low temperatures produced a hay equal in quality and feeding value to that produced by artificial drying. A stand of alfalfa in the younger stages of growth which it would have been difficult to cure by the ordinary process of hay making was converted into a protein-rich, valuable fodder by these methods.

The author admits that the favorable results were due in part to very favorable weather while the hay was curing on the racks, but points out the lesser dependence on the weather which such methods make possible, and stresses the advantage of being able to load the hay on the racks immediately after it has been mowed.

He considers that alfalfa can be preserved as silage only with great difficulty and infinite pains, and that it is barely possible to obtain a good, protein-rich fodder in this way. In his work the ensiling of alfalfa showed large losses, undesirable ammonia production, unfavorable pH, and excessive amounts of lactic and acetic acid. J.G.A.

218. Alfalfa Silage Preservation: Comparison of Phosphoric Acid and Molasses as Preservative. B. CONNER JOHNSON, W. H. PETERSON, W. A. KING, AND G. BOHSTEDT. Ind. and Eng. Chem., *32:* 12, 1622–1625. Dec., 1940.

A comparison, extending over a 3-year period, of the phosphoric and molasses methods of preserving alfalfa silage is reported. Twenty to thirty pounds of phosphoric acid per ton produced good silage. Chemical studies of this silage, compared with molasses silage (65 pounds per ton), showed the two types to have no pronounced chemical differences. Lower (to 8 pounds per ton) amounts of phosphoric acid gave a poorly preserved silage and increased the carotene losses. Both types of silage were equal in palatability and milk production and were without harmful effects upon

milk flavor. The molasses and high phosphoric acid (20–30 pounds per ton) silages produced milks higher in carotene and vitamin A than average Wisconsin winter-market milk while the milk produced on low phosphoric acid silage (8–15 pounds) was in the same carotene and vitamin A range as average winter milk. B.H.W.

219. **Fütterungsversuch mit Trockenmolke (Feeding Experiments with Dried Whey).** H. BUNGER in collaboration with E. FISSMER, W. HARRE, H. SCHMIDT, K. BOEHM, AND F. REISING. Biedermann's Zentralblatt, Abteilung B., Tierernährung, *11:* 276–300. 1939.

Extensive trials with fattening pigs and growing heifers indicate that small quantities of dried whey mixed with other concentrates constitute a satisfactory feed for these classes of livestock. The carcasses of pigs fed dried whey were normal. The nutritive effect is similar to that of the feed grains, *e.g.*, barley. It is suggested that the amount to be fed daily should not exceed a maximum of 0.5 kilo per individual; larger quantities affect the appetite adversely. The feeding of dried whey results in increased water consumption. J.G.A.

220. **Untersuchungen über den Futterwert von künstlich getrocknetem Rübenkraut und über die Futterwirkung bei Verfütterung an Milchkühe und an Arbeitspferde (Studies of the Feeding Value of Artificially Dried Beet Tops and Their Effect on Milch Cows and Working Horses).** R. EHINGER. Biedermann's Zentralblatt, Abteilung B., Tierernährung *11:* 389–427. 1939.

Digestion trials with wethers and pigs showed respectively the following digestive coefficients: organic matter, 69.9, 64.7; protein, 64.4, 46.3; fiber, 48.9, 41,7; n-free extract, 81.8, 81.8. Crude fat-negative coefficients for both species.

Drying temperature did not perceptibly influence digestion of the protein in the beet tops by wethers, but with pigs higher drying temperatures lowered the digestibility of this constituent. Digestion coefficients of the dried tops were lower for both species than the values given for fresh beet leaves by von Wedels or Kellner.

Dairy cattle relished the dried beet tops and ate as much as 6 kilos of them without unfavorable effect on either milk production or live weight. Six kilos of the tops plus a small amount of a concentrate mixture containing 17 per cent of digestible true protein were substituted successfully for a ration consisting of: alfalfa—3 kilos; dried beet cuttings—3 kilos; and beet roots—10 kilos. When the dried tops were fed production of 1 kilo of 4 per cent milk required 73 grams of digestible crude protein, 45 grams of digestible true protein, and 279 grams of starch equivalent. J.G.A.

221. Der Futterwert Künstlich getrockneter Süsslupinen (The Feeding Value of Artificially Dried Sweet Lupines). W. KIRSCH AND H. JANTZON. Biedermann's Zentralblatt, Abteilung B., Tierernährung *11:* 273–275. 1939.

Digestibility of artificially dried sweet lupines was determined in trials with wethers. One hundred kilos of dry matter contained 11.82 kilos of digestible crude protein and 10.93 kilos of digestible true protein. It is concluded that digestibility of the protein was lowered by artificial drying. J.G.A.

222. Vergleichender Fütterungsversuch mit den Kohl-rübensorten Frankenstolz und Seefelder an Milchkühen (Comparative Feeding Experiments with the Frandenstolz and Seefelder Varieties of Turnips for Milch Cows). H. BUNGER, in collaboration with E. FISSMER AND F. REISING. Biedermann's Zentralblatt, Abteilung B., Tierernährung, *12:* 14–21. 1940.

The above-mentioned varieties of turnips showed a surprisingly low content of dry matter and feed value. Both kinds were readily eaten, and when fed in equal amounts (30 kilos per cow daily) were equal for milk production and increases in live weight. J.G.A.

223. Über die Verwendung des quantitativen Indikator-verfahrens bei Untersuchung der Nahrungsforthewegung im Magendarmkanal (Employment of a Quantitative Indicator in the Study of Movement of Feed in the Gastro-intestinal Canal). L. PALOHEIMO AND M. PIRILA, A. KOSKIMEN AND T. PUOKKA. Biedermann's Zentralblatt, Abteilung, B., Tierernährung, *11:* 370–388. 1939.

The author employed Edin's chromium trioxide indicator method for ascertaining the length of time it takes for passage of feed through the digestive tract of rats and cattle.

In the trials with cattle small amounts of concentrates with a known Cr_2O_3 content were fed to 20 cows. The animals were slaughtered after varying lengths of time and the chromium content of the rumen, reticulum and omasum determined. The trials demonstrated the applicability of the method, and showed further that small amounts of concentrates are removed very slowly from the ante-stomachs. Twenty to 25 hours after feeding 16–31 per cent of the chromium remained in the rumen and reticulum and 17–32 per cent in the omasum. 48 hours later about 90 per cent of the test ration had passed the omasum. The author notes, however, that probably more rapid passage would take place if larger amounts of concentrates were fed, small amounts being impeded by the roughage in the ration. J.G.A.

224. Biochemische Studien über B_1—Avitaminose bei Tieren und Menschen (Biochemical Studies on Avitaminosis B_1 in Animals

and Man). B. CARLSTROM, K. MYRBACK, N. HOLMIN, AND A. LARSON. Biedermann's Zentralblatt, Abteilung B., Tierernährung, *11:* 322–356. 1939.

The article opens with an extensive account of the origin of vitamin B_1 deficiency. Blood analyses of various species are reviewed from the standpoint of the presence of intermediate metabolites of carbohydrate and fat in specific morbid conditions. Because of the clinical symptoms and the favorable response to thiamin administration these morbid states have been considered a result of B_1 deficiency. Substances quantitatively determined in the blood have been: Bisulphite binders, pyruvic, lactic and B-hydroxy butyric acids, and total acetone, and in some cases, α-ketoglutaric acid.

Blood examinations were made in various species and under various pathological conditions.

Of direct interest here is only acetonemia in cattle. Changes in the blood picture are of the same general trend in all species, viz.: an increase in pyruvic acid, often an increase in lactic acid, and a more or less conspicuous increase in acetone bodies. This last mentioned is extremely conspicuous in cattle, and almost entirely absent in horses.

α-ketoglutaric acid has in some cases been shown to be present in increased amounts in the blood of cattle suffering from acetonemia.

Since on treatment with aneurin (thiamin) the clinical symptoms disappear simultaneously with the return of the blood to its normal state, the authors conclude that such conditions may be regarded as cases of B_1 deficiency.

A bibliography of 50 references is appended. J.G.A.

FOOD VALUE OF DAIRY PRODUCTS

225. A Study of Two Hundred and Forty Breast Fed and Artificially Fed Infants in the St. Louis Area. I. A Comparison of Prophylactic Antirachitic Effects of 135 and 200 Unit Irradiated Evaporated Milks, 200 Unit Irradiated Fresh Milk and Human and Non-Irradiated Evaporated Milk Fortified with 800 to 1,000 Units of Vitamin D as Viosterol. EDITH C. ROBINSON. Am. J. Dis. Child., *59:* 816–827. 1940.

Two hundred and forty healthy infants were divided into eight feeding groups in which Vitamin D was supplied from five different sources. The majority of these infants were studied for at least a year. The following observations were made:

1. Positive evidence of rickets was found in the Roentgenograms in 33 per cent of the cases. In 24.9 per cent of these the appearances were those of moderate or marked rickets; in 8.2 per cent, of slight rickets. In addition, in 27.8 per cent there was "questionable" evidence of rickets.

2. Breast-fed infants, receiving 5 drops of viosterol in oil daily (800–1000 U.S.P. units of vitamin D) were protected against rickets. In one infant bone changes of active rickets developed two months after weaning.

3. Viosterol in oil in the dose of 5 drops was not sufficient to give protection against rickets in infants fed non-irradiated milk.

4. Irradiated milk containing 135 and 200 U.S.P. units of vitamin D to the quart did not protect against rickets. Two hundred unit whole milk was more protective than 200 unit evaporated milk.

5. In most of the cases, rickets healed spontaneously without increase of vitamin D during the summer months. W.H.R.

226. **A Study of Two Hundred and Forty Breast-Fed and Artificially Fed Infants in the St. Louis Area. II. Incidence of Rashes and Gastrointestinal Disturbances in Breast-fed Infants and in Infants Fed on Fresh Milk Formulas and on Acidified (Lactic Acid) and Non-acidified Evaporated Milk Formulas.** EDITH C. ROBINSON. Am. J. Dis. Child., *59:* 1002–1005. 1940.

Two hundred and forty infants were studied over a period of twenty months with respect to gastrointestinal disturbances and rashes accompanying different feedings. The following observations were made:

1. Breast-fed infants had the lowest incidence of both diarrhea and rash.

2. No advantage was seen in the use of lactic acid formulas as regards early feeding difficulties, such as colic, constipation or regurgitation.

3. Infants fed whole milk were more liable to diarrhea than those fed evaporated milk.

4. Diarrhea was slightly more common in the group receiving simple evaporated milk than in that receiving a lactic acid-evaporated milk formula. This difference was too small to be significant.

5. Infants fed irradiated milk had a somewhat higher incidence of rashes than those fed non-irradiated milk.

6. All rashes cleared up without change of milk. W.H.R.

227. **Deficiency of Vitamin C and Vitamin P in Man.** HAROLD SCARBOROUGH. Lancet, *239:* 6117, 644–647. Nov., 1940.

In the treatment of six human cases of nutritional deficiency, five of which were diagnosed as scurvy, the administration of vitamin P did not control the large subcutaneous hemorrhages or other symptoms characteristic of the scorbutic state. These symptoms were promptly arrested by large doses of ascorbic acid.

A deficiency of vitamin P may exist in man even when an excess of ascorbic acid is included in the diet. It is invariably associated with a much-decreased capillary resistance and may be characterized by the development of spontaneous petechial hemorrhages, especially in areas exposed

to pressure. Other clinical manifestations are pains in the legs on exertion, pains across the shoulders, weakness, lassitude, and fatigue. The capillary resistance is not controlled by the administration of ascorbic acid or of vitamins A, B, or D. J.F.C.

ICE CREAM

228. Vanilla. ROBERT ROSENBAUM. Ice Cream Trade J., *37:* 1, 18. 1941.

One million pounds of vanilla beans are used in the United States annually. About 60 per cent of these beans, which come from Madagascar, have been cut off due to the British blockade. The maximum crop of about 400,000 pounds, which is selling at $9.00 compared to $5.00 last year, is not likely to ease the tension in the vanilla market. Tahiti beans are moving freely but are inferior in quality; they formerly sold for $3.00 per pound but are now offered at $6.00. Should the war continue and Bourbon beans not become available the present prospect of 700,000 pounds would fall considerably short of supplying the needs. The definitions and standards committee of the International Association of Ice Cream Manufacturers has petitioned the Federal Food and Drug Administration for the use of vanillin in conjunction with vanilla beans, without qualification, in ice cream sold as "Vanilla." W.H.M.

229. The Use of Chocolate in Ice Cream. B. I. MASUROVSKY. Ice Cream Trade J., *37:* 1, 31. 1941.

In the selection of chocolate flavor for ice cream, it is important to keep in mind that:

1. The flavoring essentials are in the fat-free substance of either the chocolate liquor or the cocoa powder.
2. Chocolate liquor contains about 46 per cent fat-free substances while cocoa powder contains about 75 per cent fat-free substances.
3. Chocolate color is present in the fat-free substances of the chocolate or cocoa.
4. The proper roasting of cocoa beans influences the blending as to flavor and color of the chocolate flavoring.

The author recommends 3 per cent fat-free substance as a guide in deciding on the amount of chocolate flavoring material to use. Customers' tastes may be used as a guide to determine how much to use. Other recommendations made were to use 2 to 3 per cent more sugar than in the vanilla mix, reduce the milk solids to 9 per cent so that the total solids will be about 40 per cent, reduction in the amount of stabilizer may be desirable and in some instances 0.5 to 1 per cent egg yolk may improve whipping. Retail ice cream manufacturers may prefer to use chocolate syrup which they make themselves or which may be purchased in cans ready to use. W.H.M.

230. **An Efficient System of Quick Freezing.** TERRY MITCHELL. Refrig. Eng., *41:* 2, 101–102. 1941.

A brief resume of the Frick Company Bulletin 147–A, Frick Freezing Systems, is given stating that basically the system comprises a well insulated space with cooling coils in a bunker at the top, and push trucks, conveyors, or shelf coils below; motor driven fans keep a moderate circulation of very cold air over the foods to be frozen and back through the cooling coils. Any temperature desired down to −80° F., or even lower, can be maintained.

High heat transfer and very fast freezing are among the other advantages of the system, which is said to be used for freezing more foods than any other known method.

Refrigeration is supplied through Type VW coils, connected to suitable accumulators supplied by ammonia booster compressors, the two-stage system saving up to ⅓ in power.

The Frick system is adaptable to small scale operations such as the locker plant or to the food freezing plant where hundreds of thousands of pounds of products are frozen daily. The Hershey Ice Cream Company, of Harrisburg, Pennsylvania, is mentioned as handling in a single week's time 127,400 gallons of ice cream.

The article is accompanied with photographs and a plan layout of the system. L.M.D.

231. **Sales Trends.** O'NEAL M. JOHNSON. Ice Cream Trade J., *37:* 1, 31. 1941.

Despite adverse weather conditions sales of ice cream for the past eight months of 1940, as reported by 774 plants, showed an increase of 2.27 per cent above a like period in 1939. W.H.M.

232. **Consider Your Delivery Equipment.** B. P. FORTNEY. Ice Cream Field, *36:* 44, 59, 106, 107. Oct., 1940.

It is stated that delivery equipment should be: 1. Modern and well kept; 2. Economical to operate; 3. Dependable. No matter what the system it should provide refrigeration to carry your load all day and return any unsold ice cream to the plant in good condition.

The author points out that ice and salt as a means of supplying refrigeration is rapidly disappearing and that cartridge refrigeration, although still used, is gradually being replaced by other methods requiring less labor, and giving more satisfactory temperatures.

Dry ice using overhead aluminum plates is widely used although the daily cost of operation with this system is higher than most other types of refrigeration. In a well insulated body of 500 gallon capacity, it will require the removal of from 25,000 to 30,000 B.T.U. per day depending

upon the outside temperature in which the truck is operating. This means an operating cost of $3.00 per day or more with dry ice at 3 cents per pound plus amortization costs.

The direct expansion type has not been very successful in most delivery systems, but the partial holdover system, it is claimed, provides the most economical method of refrigeration in cases where the equipment is in use 20 to 24 hours a day during the summer. The full holdover system is very commonly used today. With this system the compressor may or may not be mounted on the truck. Many users have found the complete holdover system with the compressor mounted on the truck so that it can be plugged into an electric outlet, gives the most satisfactory and economical operation. Data is presented to show that with this system, using a fleet of bodies of 600 gallon capacity, the average daily cost of operation and maintenance depreciation amounts to 60 cents. Two tables are given in which operating cost per mile, fixed cost per mile and total cost per mile are given for varying conditions. W.C.C.

233. Function of Stabilizers. H. A. BENDIXEN. Ice Cream Field, *36:* 25, 28, 84–87. Oct., 1940.

The author states that the functions of an ice cream stabilizer are: 1. To prevent fluctuating temperatures during freezing and storage;[1] 2. To prevent coarse grainy texture in ice cream by preventing the formation of large ice crystals; 3. To increase the melting resistance of ice cream and reduce shrinkage.

It is stated that the value of gelatin as an ice cream stabilizer is due chiefly to its ability to hold water of the mix in the form of a gel. It is also claimed, that the proper amount of gelatin to use depends upon the amount of water in the mix, the gel strength of the gelatin, efficiency of homogenization and the speed of freezing and hardening.

According to the author an excessive amount of gelatin in ice cream: 1. Produces a sticky, livery body in ice cream; 2. Lowers the whipping quality of the mix; 3. Increases the cost; 4. Produces a heavy viscous mix; 5. Tends in some cases towards a stale flavor.

Starch is not satisfactory as a stabilizer since it causes a starchy custard-like flavor in ice cream. It is also stated that a number of stabilizers containing gums are sold under trade names which do not reveal the nature of the acting ingredient. Brief mention is made of the use of gums, agar, pectin and gelatin in ices and sherbets.

Previously published results obtained by the author and other investigators dealing with the use of sodium alginate as a stabilizer are discussed.

It is concluded that gelatin and sodium alginate are still the two most

[1] Abstr's note: It is difficult to see how a stabilizer could be expected to prevent fluctuating temperatures.

suitable stabilizers for ice cream, while in ices and sherbets, pectin and high grade gum may also be used. W.C.C.

234. What About Homogenization? C. C. FLORA. Ice Cream Field, *36:* 29, 72. Oct., 1940.

Homogenization, it is claimed, is designed to improve the whipping ability of mixes, to produce a smoother texture and better body in ice cream.

Certain of the improvements in the new homogenizers are indicated to show their increased efficiency.

A brief outline is given of the causes of inefficient homogenization and their relationship to: 1. Mixes with whipping ability; 2. Ice cream which appears curdled upon melting; 3. High viscosity mixes.

According to the author homogenization is one of the most important processes in the manufacture of ice cream. It should be controlled and its efficiency checked. W.C.C.

235. Casein in Ice Cream. T. R. FREEMAN. Ice Cream Field, *36:* 24, 68, 69. Oct., 1940.

Results are given of preliminary experiments regarding the preparation and use of casein in ice cream. Casein prepared from skim milk adjusted to a pH of 4.6 to 4.8 by the addition of diluted hydrochloric acid was used for these experiments.

It was found that on the basis of dissolving power, ammonium hydroxide, sodium carbonate and sodium bicarbonate ranked in the order given. Sodium hydroxide and potassium hydroxide always produced solutions which were discolored and which possessed an undesirable odor. Poor results were obtained with sodium citrate and disodium phosphate.

For the experiments in ice cream only, potassium carbonate, sodium carbonate, sodium bicarbonate and ammonium hydroxide were used. These were added to the casein in two ways: 1. In the "dry" method the required amount of "solvent" was mixed directly with the curd and allowed to stand over night; then this mixture was added to the ice cream mix during pasteurization. 2. In the "casein-gel" method enough water was added to the "solvent" and curd to standardize the mixture to 20 per cent total solids. This mixture was then heated to 140° F. for 30 minutes before dissolving it in the mix during pasteurization.

It is reported that not more than 4 per cent serum solids in ice cream should be derived from casein. Of the compounds used for dispersing the casein, ammonium hydroxide cannot be used because of an objectionable flavor in the finished ice creams. Potassium carbonate was the most satisfactory for this purpose from the point of view of flavor, body, and texture characteristics. W.C.C.

236. Dextrose and Corn Sirup for Frozen Desserts. A. C. DAHLBERG AND E. S. PENCZEK. New York State Agr. Exp. Sta. Bull., 696. October, 1940.

This investigation dealt with the use of dextrose and corn sirups to replace part of the sucrose in frozen desserts.

The relative sweetness of these sugars on a dry basis in ice cream was sucrose 100, dextrose 89, enzyme-converted corn sirup 67, and corn sirup solids 49. The freezing point depressions in water solutions increased in the following order: Corn sirup solids, sucrose, enzyme-converted corn sirup, and dextrose. The effects upon mix acidity, viscosity, and fat clumping were minor.

The most satisfactory results were secured with ice cream when 25 per cent of the sucrose was replaced by corn sweeteners. Based upon sweetness alone, a pound of sucrose was equal to 1.1 pounds of dextrose, 1.5 pounds of enzyme-converted corn sirup, and 2.0 pounds of corn sirup solids.

When used in these proportions the corn sweeteners showed slight but definite improvement in body and texture of the ice cream. This effect was sufficient to be detected by consumer preference, yet consumers were unable to determine the presence or absence of dextrose or corn sirup in ice cream. There was little effect of corn sweeteners upon hardness and melting resistance, but tendency was toward lower melting resistance.

In sherbets and ices the corn sirups improved body and texture noticeably. Both dextrose and corn sirup delayed sucrose crystallization. In ice cream, however, the dextrose did not affect the development of sandiness and the corn sirups had very little effect but tended to delay sandiness.

Author's Abstract.

237. Selecting Chocolates. P. S. LUCAS. Ice Cream Field, *36:* 34, 102, 103. Oct., 1940.

The public has become accustomed to milk cocoa types and bitter sweet types according to the author. This is largely a result of activities of candy and breakfast cocoa manufacturers, but it is to the interest of ice cream manufacturers to take advantage of these potential demands.

Brief mention is made of the more common varieties of cocoa beans grown in South America and Africa which serve as the main sources of supply of such raw material.

Results are given of consumer preference tests on seven different types of cacao bean which served as sources of flavor in ice cream, and these are compared with opinions of experienced judges. The experienced judges preferred the mild flavored South American cacaos, whereas consumers preferred a more pronounced chocolate flavor. Despite this difference there was fairly good agreement between the preferences of the two groups. It is concluded that good quality chocolate flavor will sell better than less desirable types. W.C.C.

238. Modern Ice Cream Freezing. G. O. WYMOND. Ice Cream Field, *36:* 38, 98, 99, 102, 103. Oct., 1940.

The author briefly outlines the recent developments that have occurred with batch and continuous freezers. The trend has resulted in faster frozen ice cream, but it is pointed out the continuous freezer is better adapted for fast freezing than is the batch freezer.

Oil accumulation in the continuous freezer is more serious than in the batch freezer. Excessively low back pressures are sometimes used to prevent decreased rate of freezing but such practices are costly. Precautionary steps which can be taken are discussed.

The author states that many oil difficulties are eliminated with multiple stage refrigeration, *e.g.*, where a booster is used as the first stage and the compressor used as the second stage with inter-cooling between stages.

It is concluded that small batch freezers (usually 40 quart capacity) will always have a place in both large and small ice cream plants. Large batch freezers are not now being manufactured or sold according to the author because the larger the freezer the greater the variation in overrun as the ice cream is discharged. In the most modern ice cream freezing methods the continuous freezer is considered best because, the author states, it freezes colder, requires less attention from the operator, produces a more uniform product, is continuous in operation and permits the use of various filling devices. W.C.C.

MILK

239. Control of Production and Daily Losses in Milk Bottling Plants. HANS EDEL. Milk Dealer, *30:* 4, 30–31, 64–65. Jan., 1941.

The author presents a "bottling order form" and a "daily production report," which when used as described make a quick and convenient method of determining production and losses in bottling plants. The bottling order form contains information which may be used to determine the trips per bottle, the amount and cost of washing materials used per 1,000 bottles, etc. C.J.B.

240. What Are the Extra Costs of Requirements for the Production of Fluid Market Milk Over Milk for Manufacturing Purposes? PAUL YOUNG. The Assn. Bull., Internat. Assn. Milk Dealers, 33rd yr., No. 11, 291–298. Jan., 1941.

It is suggested that whatever method is used, producer prices for fluid milk should be kept in sound relationship with manufactured product prices.

Results of a recent study of the extra costs of producing fluid milk over evaporated milk made by the National Dairy Products Corporation are given concerning 376 farms in 11 markets. The results are as follows:

Average	extra	costs	of	improvements	per	100	lbs.	.....	$.0213
"	"	"	"	equipment	"	"	"	.....	.0211
"	"	"	"	supplies	"	"	"	.....	.0617
"	"	"	"	labor	"	"	"	.....	.1385
"	"	"	"	transportation	"	"	"	.....	.0911
							Total	.....	$.3337

To the above figure should be added an extra cost to provide an inducement sufficient to attract an adequate supply of milk. The evaporated milk code price is suggested as a suitable measuring stick.

Somewhere above the 33 cents cost figure given above and below the present market milk premium over evaporated milk will be found an appropriate price for market milk. E.F.G.

241. Use of Two and Four Quart Bottles and Examination of Distribution Costs in Search of Saving. A. J. BERGFELD. The Assn. Bull., Internat. Assn. Milk Dealers, 33rd yr., No. 12, 301–306. Jan., 1941.

The figures given are the result of actual time studies in several dairies who had been using these packages over one year and who individually average about 2,500,000 units per month.

CHART 1. AVERAGE PACKAGE AND PLANT COSTS PER THOUSAND QUARTS

	1 quart	2 quart	1 gallon
1. Package Costs			
Bottles	$1.330	$1.125	$ .815
Caps	.339	.200	.441
Hoods	.....	.....	.....
Cases	.261	.245	.244
Total package costs	$1.990	$1.570	$1.500
Package cost savings		$ .420	$ .499
2. Plant Costs			
Receiving—Labor	$ .459	$ .358	$ .331
Expense	.564	.616	.472
Washing—Labor	.387	.428	.383
Expense	.745	.664	.530
Filling—Labor	.388	.404	.398
Expense	.457	.378	.412
Platform—Labor	1.024	.794	.742
Expense	.902	.726	.628
Total plant labor	$2.258	$1.984	$1.854
Total plant expense	2.668	2.384	2.042
Total plant costs	4.926	4.368	3.896
Plant cost savings		.558	1.030
Total package and plant costs	6.916	5.938	5.396
Total savings per thousand quarts		$ .978	$1.520
Total savings per quart		$ .001	$ .0015

	Range Included in Average		
Washing speeds per machine	180–82	75–30	44–15
Filling speeds per machine	115–82	75–30	44–15

No figures for route savings are given but time studies show only 25 per cent of the drivers' working day is spent in handling packages. It is the belief of the writer that the larger container does not greatly reduce cost per quart in delivery; and that delivery costs should be figured per stop and that distribution costs can be lowered only by changing consumer buying habits. E.F.G.

242. Methods of Producing High Quality Table Cream. O. J. SCHRENK. Milk Dealer *30:* 4, 41–44. Jan., 1941.

Emphasis is placed on the necessity of obtaining cream from a high quality milk and preserving its flavor by using equipment that is clean and sterile and made of metals that will cause no off flavors. It is pointed out that viscosity may be increased by homogenization or by temperature control. Homogenization is also recommended to prevent the formation of a skim milk layer. The necessity of low-pressure homogenization in order not to induce feathering is emphasized. Churning is given as the main cause for cream-plug formation and the presence of butter granules and flakes. C.J.B.

243. Experiences with the Multiple Container. FLOYD M. KELLER. Milk Dealer, *30:* 4, 76–78. Jan., 1941.

Experiences with the multiple container in Chicago show that the anticipated savings in distribution costs by making deliveries less frequently to offset the reduced price was never generally realized. This has been largely due to the fact that the present union wage contract is based on units sold rather than delivery stops made. The sale of by-products also dropped off when less frequent deliveries were made.

The cost of putting a gallon jug of milk on the platform is about the same or slightly less than that for four single quarts of milk. A gallon cap costs a little more than twice as much as a cap for a single quart. The cost of putting a half-gallon jug of milk on the platform is less than two single quarts. There is a 50 per cent savings alone on caps and the labor required for washing and filling is less.

Another point brought out is that with the multiple container some people have delivery once or twice a week, which is a trend away from fresh milk.

The author concludes that the feeling at the present time is that the gallon jug is not a satisfactory package for milk, while the half-gallon has met with more favor, both with dealer and customer, and apparently is here to stay. C.J.B.

244. Control of Heat-Resistant Bacteria. A. C. MAACK. Milk Dealer, *30:* 4, 84–87. Jan., 1941.

The milking machine was found to be the most frequent source of thermoduric organisms. It is pointed out, however, that any piece of equipment which has dried milk solids adhering to it is an excellent source of contamination.

Improper can washing and sterilization, repasteurization of returned products, foam, and milk stone are given as likely to cause the presence of thermophiles. To prevent original contamination with thermophiles on the farm it is recommended that dust be kept down during milking time, utensils be scalded or steamed and then dried quickly, and that the milk be properly cooled. C.J.B.

245. Problems in Handling Glass Containers for Milk. J. H. TOULOUSE. The Assn. Bull., Internat. Assn. Milk Dealers, 33rd yr., No. 9, 223–234. Jan., 1941.

Sixteen dairies are covered in this study. Breakage in the plant can be held to around 0.5 per cent or at the worst 0.75 per cent. Thermal shocks, impacts and pressure each produce characteristic patterns which are recognizable. Ripple marks, hackle structure, and feathers are examples of perhaps a dozen different types of fracture. Sometimes failure of the bottle may proceed in three stages as, for example, an impact causing a "bump-check" (first stage), a temperature shock causing a "butterfly bruise," and finally hydrostatic pressure completing the injury. To a larger extent than is realized breakages are chain affairs, final failure resulting several trips after the real injury. The finish of a bottle is most frequently injured, almost half the breakage loss being due to finish damage. The heel or rounded bottom of the bottle accounts for $\frac{1}{4}$ to $\frac{1}{3}$ the loss, shoulder impacts $\frac{1}{6}$ and side wall injuries $\frac{1}{8}$ of total losses. Bottles break at a reduced rate during the first two years of service and at an increasing rate thereafter.

Normal operations and machines that contact the finish cause 44.3 per cent of all damage. Whenever the same injury predominates and the same breakage pattern is formed it indicates a single place and cause is responsible and gives reason for investigating the handling of the bottle to discover the place of injury. A good average life of a milk bottle is 2.0 to 2.3 years.

Bottle losses may be reduced by repair and maintenance of bottling equipment, watching casing operations, removing injured bottles before filling, exact determination of breakage by weighing broken glass daily. E.F.G.

246. Progress Report on Lighting in Milk Processing. J. O. KRAEHENBUEHL. The Assn. Bull., Internat. Assn. Milk Dealers, 33rd yr., No. 9, 235–245. Jan., 1941.

Physically the human eye developed out of doors under conditions of

far vision. Indoor work places an extra load on vision under low light conditions. The result is eye strain, nervous strain, with many secondary ailments following. Increase of illumination lessens nervous strain and allows a better perception of the task and greater agility in performance. Wiring of new buildings may be made double the legally required capacity at 30 per cent to 50 per cent increase in cost and thus keep voltages at maximum efficiency. A 300 watt lamp burned at 10 per cent under voltage has been found to waste 92 cents worth of electricity during the 1,000 hours burning life of the lamp. A total gain of 51 per cent in illuminating efficiency has been obtained by the following: repainting, 12 per cent; cleaning lamps and reflectors, 20 per cent; proper voltage new lamps, 19 per cent.

In the dairy plant, tasks requiring critical inspection as bottle removing and inspection will need 100 foot-candles or more; machines equipped with gauges and thermometers, 25 foot-candles or more; general lighting, 20 foot-candles and storage areas, etc., 5 foot-candles. Actual measurements in representative dairy plants have shown illumination of the order of 1/5 to 1/10 of the recommended foot-candles. More detailed recommendations are to be presented through the I.E.S. and the I.A.M.D. later. E.F.G.

247. Differentials for Class 1 Milk over the Evaporated Code Price. R. K. Froker. The Assn. Bull., Internat. Assn. Milk Dealers, 33rd yr., No. 11, 283–290. Jan., 1941.

Extent of the differential needed depends upon nature of pricing structure, quality standards and their administration, uniformity and increasing or decreasing demand, and production and competitive conditions. In the Madison, Wisconsin, market 10–20 per cent over condensery prices maintained an adequate supply of milk prior to the depression of '30's. Now class 1 milk is $2.60 and milk for cream purposes 25 cents over evaporated milk code price. Daily production per farm has increased from 188 lbs. in 1927 to 267 lbs. in 1939. Probably the most important factors back of the present prices in the Madison market are state control, a strong producers organization and a partially restricted market. Chicago milk prices since September 1, 1939, have been based upon the evaporated milk price, December to April, 55 cents over; May–June, 45 cents over and July to November, 70 cents over. Fourteen hundred new producers were taken on during the year. In New York City from August to December premiums averaged fully 75 cents per 100 lbs. over western condensery prices.

Free competition in the distribution of milk would mean abolishing certain corporate privileges, registered trade names, etc. Free competition in labor would mean abolishing certain labor union practices, the adoption of a wage scale taking into account the income to labor in other lines including W.P.A. and the unemployed. Farmers would certainly look with more

favor upon purely competitive pricing of their milk if such a policy were also followed with reference to pricing, management, capital and labor.

E.F.G.

248. Loss of Fresh Milk Sales to Evaporated Milk and Related Farm Price Policies. C. W. PIERCE. The Assn. Bull., Internat. Assn. Milk Dealers, 33rd yr., No. 11, 275–282. Jan., 1941.

The uses to which evaporated milk is put in the home indicate that it competes mainly with cream and cooking milk. One third of 813 families in Johnstown, Pennsylvania, using evaporated milk gave price as the reason, 20 per cent because it was richer and 15 per cent because it was better for a particular use. A definite preference for evaporated milk was found in many families using a half-and-half coffee mixture. Many people seem to like the flavor of the mixture and the lower price of evaporated milk is a secondary consideration.

A flexible class 1 price tide in with the evaporated milk formula is suggested. This would cause seasonal variations. It would place producers in a position to expect distributors to adjust operating costs so that fluid milk could compete more effectively with evaporated milk. E.F.G.

249. A Study of the Influence of Federal and State Regulation upon Returns to Milk Producers and Prices to Consumers. W. A. WENTWORTH. The Assn. Bull., Internat. Assn. Milk Dealers, 33rd yr., No. 10, 251–267. Jan., 1941.

The fluid milk market reports of the Agricultural Marketing Service of the United States Department of Agriculture were used as a basis for this study. Seventy-four markets for which sufficiently complete information was obtained were divided; 36 were with price control in effect and 38 were without price control.

Distributors' cost of milk going into the bottle during the period from January 1, 1938, to August 31, 1940, averaged six tenths of a cent higher in cities where prices were fixed by government than in other comparable cities. This greater cost resulted in a price to the consumer nearly two-thirds of a cent higher per quart in the cities where price control was in effect. The farmers received a net average price for all the milk they produced only one fifth of a cent per quart higher than in markets where government does not set the price. In some individual markets the return to the farmer was actually lower under government control due to stimulation of production by a high class 1 price. It is stated that price fixing in the milk industry seems to be an established principle but farmers and official agencies must recognize that the bottle of milk should not carry the burden of earning a fair price to farmers producing a volume of milk greatly in excess of the market consumption. Detailed tables show the re-

sults by cities in each geographical section and averages are calculated separately for 1938, 1939 and the first 8 months of 1940. E.F.G.

250. Cost Reports for Operating Heads. HARRY E. HOWELL. The Assn. Bull., Internat. Assn. Milk Dealers, 33rd yr., No. 12, 307–313. Jan., 1941.

An important differentiation is between standby costs (those which exist whether we produce or not) and variable costs (costs arising in a constant ratio with production). Reports should be directed to the individual who has authority to do something about the conditions which they reveal commonly falling into one of two classes; 1. corrective and 2. controlling. The former should probably not become routine while the latter should be simple, readable, and remain unchanged in design. The controller who by stepping beyond the restraining concepts and conventions of strict accounting to make his reports profit-making tools of management has justified his work. E.F.G.

251. Is Pasteurization Necessary? H. BARKWORTH. Dairy Industries, *5:* 11, 285. Nov., 1940.

The author points out that since 1900 there have been 147 officially reported milk-borne epidemics in the United Kingdom involving 14,000 individuals. The incidence of the epidemics is shown as well as a list of the diseases involved. In summarizing his discussion he appreciates that the present method of pasteurization is not ideal but that for the present time it must at least be admitted a necessary expedient. D.V.J.

252. The Effect of the Time and Temperature of Pasteurization upon Some of the Properties and Constituents of Milk. R. F. HOLLAND AND A. C. DAHLBERG. New York State Agr. Exp. Sta., Tech. Bull. 254. Oct., 1940.

Studies have been made of the effect of the time and temperature of pasteurization of milk upon cream volume, the phosphatase test, the destruction of *Escherichia coli*, the rennet coagulation time, the calcium phosphate salts, and some of the nitrogenous constituents of milk.

In order that the time required to heat the milk to pasteurization temperature might be as brief as possible, the heating of the samples was accomplished in a thin-walled, rectangular, tinned copper tank $20 \times 12 \times 1$ centimeters which could be immersed in a series of hot water baths.

The temperatures of pasteurization ranged from 140° to 175° F.

A semi-logarithmic relationship between the time and temperature of pasteurization was found in the case of the cream volume, the phosphatase inactivation, and *Escherichia coli* destruction.

The effect of usable times and temperatures of pasteurization on the rennet coagulation time of the milk was shown to be a slight increase in every case.

No significant changes in the relative amounts of $CaHPO_4$ and $Ca_3(PO_4)_2$ were found by the method of Ling at times and temperatures which might be useful for commercial pasteurization.

The above was found to hold true in the case of casein and heat coagulable protein. Residual nitrogen was increased by heating in nearly every case.

A point was found at 170° F. which appeared especially promising as a new standard for pasteurization. This has not yet been investigated on a commercial scale, however.

Author's Abstract.

253. What Does Quality in Milk Really Mean? RUSSELL J. DAVIS. Milk Dealer, *30:* 3, 36–37, 66–74. Dec., 1940.

A discussion of quality in milk based mainly on the following factors:

Quality in milk is discussed from the standpoint of sanitary factors, food value, and discriminating characteristics. The sanitary factors are divided into sanitary supervision, safety, foreign matter, and uniformity. Food value is discussed under the following topics: Food value below the cream line, vitamin content, mineral salts, and butter fat. The discriminative characteristics include flavor and appearance. C.J.B.

254. What About the Multiple Quart Container. EDWARD THOM. Milk Dealer, *30:* 2, 37, 72. Nov., 1940.

Of the replies received on a nation-wide questionnaire, 80 per cent advised they were using either two-quart or gallon jugs at the present time. Areas heard from, however, were spotty, indicating that non-users ignored the questionnaire. Of the 80 per cent who advised they used multiple quart containers; 36 per cent revealed they were using only the two-quart bottle, three per cent were using only the gallon jug, and 41 per cent were using both the two-quart and four-quart containers.

Something like 52 per cent of the milk dealers contacted reported the savings or possible business increases were not enough to offset lower gross revenue; 24 per cent indicated increase in sales and savings resulting from handling larger units more than offset the loss of revenue due to lower selling price per quart; and another 24 per cent declared it was an even break—one advantage offset the other.

The private views of some of the milk dealers handling multiple quart containers are also given. C.J.B.

255. Survey Indicates Trend in Sale of Certified Milk. ANONYMOUS. Milk Dealer, *30:* 2, 35, 73. Nov., 1940.

Reports received from 14 states and the District of Columbia showed that

the trend in sales of certified milk is definitely downward. The survey also showed that the price of certified milk ranged from 2 to 8 cents higher than the price of the standard milk delivered. It further showed that the average percentage of certified milk sales to all milk sales is less than one per cent. The percentage of sales varied from none to four per cent. C.J.B.

256. **Cash and Carry vs. Home Delivered Prices.** J. A. ROGERS. Milk Dealer, *30:* 2, 31, 50. Nov., 1940.

A study of milk sales in New Jersey showed that there has undoubtedly been a drop in store sales during 1940 as compared with 1939. This was true in those areas where there was a differential of one per cent per quart of milk between sales from stores and the price charged on the route, as well as in those areas where this differential had been eliminated. The decrease in store sales is attributed to: Low cost of canned milk in the stores; chain stores changing over to the super-market; increased employment and purchasing power causing many people to purchase milk from the route who formerly obtained it from the store; and unfavorable weather which existed in the State last summer, summer being the season when New Jersey sales expand owing to sea-shore trade. C.J.B.

257. **Trypsin—An Anti-oxygen for Milk.** F. J. DOAN AND G. M. MILLER. Milk Plant Monthly, *29:* 9, 42–47. 1940.

The proteolytic enzyme trypsin was a very effective anti-oxygen for inhibiting or delaying the oxidation of milk which results in tallowy flavor, the effect being contingent on a short period of enzymatic action, since heated trypsin was inert as an anti-oxygen. The amount of trypsin required to protect milk for a 48-hour period was very small. A quantity in excess of 0.00128 per cent was effective in the presence of 2 p.p.m. of added copper sulfate. Proteolysis, resulting in bitter flavor and coagulation of the milk on boiling, became noticeable when the amount of trypsin used exceeded 0.00640 per cent, but the threshold value would naturally vary somewhat depending on the time allowed for enzymatic action before pasteurization.

The anti-oxygenic effect of trypsin in milk apparently was not explained by the hypothesis that sulfhydryl compounds were produced by the action of the enzyme on the proteins, since no nitroprusside reaction was obtainable and since there was no measurable stabilizing effect on the reduced ascorbic acid. However, it does not preclude the probability that reducing substances of some kind result from tryptic action in milk. G.M.T.

258. **Cooling Milk at the Farm.** JOHN E. NICHOLAS. Milk Plant Monthly, *29:* 7, 23–27. 1940.

By means of thermocouples the actual temperatures of layers of milk within 10 gallon cans under different conditions of cooling were determined.

Exposure of the cans four inches above the water level of the tank and with a water to milk ratio of 3.25 resulted, after 1¼ hours agitation of the water, to wide ranges in temperatures between the upper and lower layers of the milk. The bottom of the milk was below 50° F. within 15 minutes of cooling, but 9¼ hours were required to bring the top of the milk to this temperature. After one hour of cooling the top and bottom milk in the same can was 78.8° and 46° F., a difference of 32.8°. When the milk can was not sufficiently submerged, which was often the case when but two cans of milk were placed in a four-can tank, use of a spray or sprinkle system of cooling resulted in temperatures at the top and bottom of the milk at the end of the first hour of 52.3° and 45° F. respectively. Two methods of obtaining initially large amounts of available refrigeration were by using a large water to milk ratio, a 10 or 12 to 1, or a smaller water to milk ratio 1.6 or 1.8 to 1 with ice on the evaporating coil. The importance of agitation even with sufficient refrigerating capacity was demonstrated. The modern electric milk cooler gives remarkable performance and is an economical investment. G.M.T.

259. Studies of the Resazurin Test for Milk. J. M. BRANNON. Milk Plant Monthly, *29:* 5, 51, 54–55. 1940.

The resazurin test was found to be somewhat faster than the methylene blue test in detecting poor-quality milk, although occasionally little difference was noted. The methylene blue test was simpler and involved but one color change, whereas the resazurin test might go through several color changes. Until technicians had had more experience with the resazurin test it seemed advisable they continue to use the methylene blue test and, when possible, in conjunction with the direct microscopic count. Data are presented, classifying milks according to these two tests and by microscopic and by plate counts as well. G.M.T.

260. The Effect of Holder and Flash Pasteurization on Some Flavors of Milk. ROBERT D. MACCURDY AND G. M. TROUT. Milk Plant Monthly, *29:* 11, 44–47, *29:* 12, 53–58. 1940.

Samples of milk from each of 10 producers were obtained weekly over a six-months period and were holder-pasteurized with and without aeration at 143° F. for 30 minutes and flash-pasteurized at 160° F. for 15 seconds. The samples were scored and rescored "blind" at the first and third days of storage by two judges working independently.

The pasteurization process increased the frequency of heated, oxidized, cooked, and old flavors, and decreased the frequency of feed, high-acid, flat, salty, cowy, rancid, unclean, and off but unidentified flavors.

Storage of the milk at 40° F. for three days increased the frequency of high-acid, old, oxidized, unclean, and rancid flavors in the raw samples and the oxidized and old flavors in the pasteurized samples, whereas similar

storage decreased the percentage incidence of "feed," "cowy," "flat," "heated," "cooked," and "off" but unidentified flavors.

The mean score of the raw milk of all patrons decreased steadily from January through June. A gradual increase in the incidence of feed flavors was found in the raw samples from January to June. During the same period of time there was noted a rather constant frequency of oxidized flavors in the samples of the pasteurized milk, until May when the frequency decreased markedly. As the frequency of feed flavors increased, a very similar decrease in the occurrence of the oxidized flavors was noted.

When the cows were fed a given quantity of silage the feed flavor was more intense in that milk from the cows of least production. Feed flavors were noted in the milk when 0.79 pound of corn silage or 0.40 pound of alfalfa silage per pound of milk produced were fed to the cows one hour before milking.

Alfalfa and corn silage flavors in milk were lessened in intensity by holder pasteurization. However, strong silage flavors were not entirely eliminated by the process employed. Vacuum holder pasteurization and forced aeration holder pasteurization were superior to unaerated or aerated holder pasteurization in removing corn and alfalfa silage flavors from milk. These processes were superior also to flash pasteurization in removing corn silage flavor from milk. Unaerated and aerated holder pasteurization resulted in a greater frequency of oxidized flavors in the stored milk than did vacuum pasteurization.

A small quantity of silage flavored milk may not necessarily taint the flavor of a large batch of processed milk. Sufficient excellent flavor milk may be added to the silage milk to reduce the intensity to the extent that pasteurization will remove the flavor entirely. Author's Abstract.

261. The Characteristics of Chocolate Dairy Drinks. K. G. WECKEL. Can. Dairy and Ice Cr. J., *19:* 8, 42. 1940.

Chocolate milk is characterized by its flavor, color, body, physical appearance, curd tension and nutritive value. The caloric value of chocolate milk is usually higher and the vitamin A content usually lower than whole milk. The color of chocolate milk is a matter of preference but gray, uneven and anemic colors should be avoided. Homogenization results in a lighter color. Predominant use and increased sales of nonsettling chocolate milk indicates consumer preference. Absence of sediment simplifies the consumer's use of the product, ensures utilization of nutritional and flavor factors and reduces the difficulty of washing emptied bottles. Zoning or stratification may be due to temperature differences in the bottle due to slow cooling and to lack of viscosity, agitation in the vat while cooling or uniformity of particle size of the cocoa. "Marbling" may be caused by aging, agitation or rough treatment of the bottle during transportation. If frequent

or continuous use of chocolate milk in the home is desired, avoid high intensities of flavor. Viscosity or "body" helps maintain the suspension and imparts a sense of richness. Chocolate milk products possess an extremely low curd tension. O.F.G.

262. Effect of Government Regulation on Milk Production. HOLTON V. NOYES. Assn. Bull., Internat. Assn. Milk Dealers, 33rd yr., No. 5, 137–147. Dec., 1940.

State control from 1933–1937 was not effective because of inability to control milk originating outside the state of New York. Unsettled conditions following the breakdown of state control resulted in extremely low prices to producers. Joint federal and state authority was made possible later by the marketing provisions of the Federal statute and the New York State Rogers-Allen law. Under these two laws minimum prices can be fixed for both interstate and intrastate milk. With the present law during the period October 1, 1939, to October 1, 1940, there has been for the first time in many years a stable market in the metropolitan area. Returns to producers have been at a higher average than for any period since 1933. There has been no reduction in consumption of fluid milk. However, the author feels that some controls need be devised to limit the amount of milk which may be produced under the present system or surpluses will be excessive. Only about one third of the fluid milk available for the New York market in June, 1940, was needed for fluid milk in that month. E.F.G.

263. Influence of Federal and State Regulation upon the Volume of Sales of Fluid Milk. LELAND SPENCER. Assn. Bull., Internat. Assn. Milk Dealers, 33rd yr., No. 5, 148–156. Dec., 1940.

The price of milk in 6 unregulated markets was 1.8 cents per quart lower in the first 8 months of 1940 than the average of the predepression years 1926–1930. The same comparison for 9 markets under state or federal control shows a reduction of .9 of a cent. However, too little is known about the contributing causes of price changes to justify definite conclusions as to the proportion of the price effect which is due to government regulation. However, it cannot be doubted that the general level of retail milk prices has been raised by the state and federal milk control programs. Also the cost of milk to families in the lower income brackets has been raised the most. Probably the price paid for fluid milk by the low-income groups in most markets under public control has been at least one cent and perhaps as much as two cents a quart more than it would have been in the absence of such control.

With a 2 cent rise in the retail price of milk last year the consumption seems to have dropped about 3 per cent based upon receipts of milk by rail and truck within the New York metropolitan area. This has occurred in

the face of better business conditions which would normally result in increased milk consumption. The conclusion seems justified that consumption of fluid milk in those markets where prices are regulated by state and federal authority is from 2 per cent to 5 per cent less than it would be under unregulated industry competition. E.F.G.

264. "Jug Station" Milk. Editorial. J. Am. Med. Assn., *115:* 1724. 1940.

"Studies by the United States Public Health Service and the former American Child Health Association have demonstrated again and again that milk-borne epidemics are due almost exclusively to raw milk supplies.

"Even today bootleg milk stations, also called 'jug stations,' still operate outside the jurisdiction of some cities in which only pasteurized milk, other than certified, is legal. When every possible legal precaution has been taken to protect a community against potential dangers in raw milk, and milk consumers persist in circumventing the local regulations by buying milk from unsupervised sources, the occurrence of milk-borne outbreaks of communicable disease cannot be attributed to any failure on the part of the health authorities. Unless county and state health authorities cooperate with city officials in controlling this menace to health, outbreaks of milk-borne infection are bound to occur." D.P.G.

265. Emergency Labels of Unpasteurized Milk. Editorial. J. Am. Med. Assn., *115:* 1369. 1940.

In many localities it now is illegal to distribute unpasteurized milk, except certified milk, for which pasteurization is permissive rather than mandatory. While equipment for pasteurization has been improved in many ways, it still is impossible to safeguard the pasteurizing plant against all the causes of breakdown. To meet such an emergency, the New York State Department of Health has devised a collar to be slipped over the milk bottle bearing the warning that milk so labeled has not been pasteurized and that it should be boiled before using. The text of the warning is as follows: Raw milk—Warning—Due to an emergency over which the dealer has no control, this product is raw instead of pasteurized as labeled. Play safe and boil before using. D.P.G.

266. A Notable Pasteurization Record. Editorial. Am. J. Pub. Health, *31:* 1, 82–83. 1941.

The Provincial Legislature of Ontario made pasteurization of milk compulsory in 1938. This editorial describes the progress of the program as reported by A. E. Berry of the Ontario Department of Health at the meeting of the Canadian Public Health Association. After two years of this new

legislation, it is estimated that at least 92 per cent of all milk sold in Ontario for fluid consumption is pasteurized. There appears to have been a very favorable effect on the number of cases of undulant fever, which in 1939 was reduced by 45 per cent, and in the number of cases of typhoid fever, which was lowered approximately 50 per cent, the infant mortality being also reduced substantially. M.W.Y.

267. Further Observations on the Rapid Phosphatase Test. H. SCHARER. Am. J. Pub. Health, *30:* 10, 1206–1210. 1940.

The New York City Department of Health has made more than 150,000 phosphatase tests in the past two years. Both the laboratory and field tests were used. The limits of sensitivity of each test and precautions to be observed are discussed. Borax was found to be the only common preservative which could be effectively employed in samples to be examined by the phosphatase test. Directions are given for avoiding errors due to decomposition of reagents. M.W.Y.

MISCELLANEOUS

268. Report of a Conference of Cold Storage Locker Operators. J. H. L. TRUSCOTT. Can. Dairy and Ice Cr. J., *19:* 7, 44. 1940.

The locker-storage business has made remarkable growth in Ontario during the past year. The need for standardization of prices for services is realized. A well organized locker plant should include: 1. A chilled receiving room; 2. A chilled meat aging room; 3. A preparation room containing cutting block and tools, table, scale, grinding machine and wrapping machine; 4. A sharp freezer; 5. The locker room; 6. A machine room; 7. A public room; and 8. A small office. Freezing rates for fruits and vegetables must be fast. O.F.G.

269. Sanitation Management in Dairy Plants. H. TRANMAL. Can. Dairy and Ice Cr. J., *19:* 7, 22. 1940.

To facilitate the cleaning of dairy equipment milk solids must be kept in soluble form. Heating and drying cause the precipitation of milk solids and make them difficult to remove. Soap is of low cleaning value for dairy purposes because the alkali is partly spent and is difficult to use in hard waters. Too strong alkalies cause spangling and dissolving of tin from equipment. Stainless steel is most easily cleaned with strong washing solutions and a good brush. Deposits of milk stone may be removed easily with the help of weak acids and a metal sponge. Directions are given for the cleaning of farm dairy equipment. At 50 cents per hour, 3 minutes of a man's labor will buy one pound of trisodium phosphate. Extreme care should be exercised in using chlorine solutions on tinned copper as the chlo-

rine easily dissolves the tin. Sterilization of equipment just before use is preferred. Hot water, steam and chlorine solutions are listed in the order of their preference. O.F.G.

270. Seasonal Labor Problems. I. R. KRILL. Can. Dairy and Ice Cr. J., *19:* 7, 19. 1940.

Handling of the seasonal labor requirements involves: 1. Selecting workers who are apt and reliable; 2. Integrating the labor of new employees in such a way as to maintain efficient production and avoid waste; 3. Managing by wise foresight and a few simple precautions to keep at a minimum the expense of industrial insurance. The best market for summer labor is found in two groups: 1. Women and girls who are seasonably employed in the winter; 2. Students who in the off-season are attending school. O.F.G.

271. Fly Control for Dairy Plants. W. H. POHLMAN. Can. Dairy and Ice Cr. J., *19:* 6, 22. 1940.

The fly is an expensive insect, not only in the matter of spoilage but also as a health menace. The methods of control can be divided into two sections as follows. Section 1. Prophylactic Methods—a. In the territory adjacent to and surrounding the plant property, b. In the plant proper; Section 2. Plant openings—a. Proper closure of all openings in the processing department, b. Erection of devices as barriers at points through which normal traffic flows, c. Elimination of superfluous or unnecessary openings. A knowledge of the life cycle and habits of the fly is necessary for effective control. The use of spray curtains, door barriers and electric screens is discussed. O.F.G.

272. Information Please. Will Business Supply the Answers? MABEL G. FLANLEY. Assn. Bull., Internat. Assn. Milk Dealers, 33rd yr., No. 3, 80–88. 1940.

A recent poll for Food Industries by Hartwell, Jobson and Kibbee indicated that the dairy industry rated the lowest of all food industries in public esteem. Also the dairy industry rated lower than the drug and cosmetic industry. Fifteen per cent of those who disliked the industry did so because of products and 68 per cent because of industrial practices. Twenty-three per cent definitely believed in government-owned food industries, placing the milk and dairy business second only to meat on the list. Consumer cooperatives and the government are furnishing the house-wife with much information. Dairy interests should formulate more comprehensive public relations and public education programs. The desirability of cultivating "key groups" and active cooperation with the new federal government Consumer Protection Division are discussed. E.F.G.

273. National Defense Advisory Commission. GEORGE M. MOFFETT. Assn. Bull., Internat. Assn. Milk Dealers, 33rd yr., No. 2, 61–63. 1940.

Attention is called to the vital importance of good health and good humor in making an adequate defense effort possible. The advisory commission through its Consumers Division is paying particular attention to the more widespread consumption of milk and the other protective foods. E.F.G.

274. Trends in Social Security Legislation. GEORGE GUTH. Proc. 40th Ann. Conv. Int. Assn. of Ice Cream Mfrs., *1:* 41. Oct., 1940.

The present Social Security Act was enacted in 1935. The speaker discusses various provisions of the act and how they are working out in actual practice. For many employers Federal and State social security taxes are the largest taxes they pay. Hence, employers should see that they reap all the benefits possible as a return on this large investment. M.J.M.

275. Trade Barriers—A Menace to Business. PAUL T. TRUITT. Proc. 40th Ann. Conv. Int. Assn. of Ice Cream Mfrs., *1:* 91. Oct., 1940.

That state trade barriers are extensive is shown by the fact that 41 states have enacted laws giving residents some kind of preferences over non-residents. Of particular interest to the dairy industry are the barriers erected between states of conflicting or duplicate inspection requirements for dairy products.

Trade barrier laws do not necessarily on their face discriminate against out-of-state enterprise. Laws may become discriminatory in practice or by unfair administration. The enactment of these barriers is by the abuse of one of the sovereign state powers, as taxation, police power for the protection of public health, or public welfare, or the power of the state in the protection of its own natural resources.

Possible approaches to the problem are through the regulatory power of the Federal government, cooperation between states working toward uniformity in regulations, or by joint action between states and the Federal government. A program should be instituted with the two objectives of preventing the enactment of new trade barrier laws and the repealing of those already in force. In view of the uncertainty of the foreign trade outlook, self-interest demands a united effort on the part of American businessmen to preserve the world's greatest area of internal free trade. M.J.M.

276. Safety Programs Pay Dividends. E. H. ROWLAND. Proc. 40th Ann. Conv. Int. Assn. of Ice Cream Mfrs., *1:* 82. Oct., 1940.

It is estimated that the indirect loss to employers by accidents is roughly four times as much as the premium spent for compensation insurance. This

fact shows clearly the need for the prevention of accidents in production and distribution.

Preventing accidents requires a knowledge of the unsafe acts or operating conditions that cause them. Slippery floors, improperly constructed ladders, steam leaks, conveyors and other moving machinery are cited as serious hazards. Salesmen and truck drivers need to be observed periodically by a person trained in road supervision.

Many accidents are preventable. Only by proper consideration of this important problem by the executives of a company, who are willing to devote the necessary time and thought to a sound program, will the number of accidents be materially reduced. M.J.M.

277. **Training in the Public Service in New York State.** ALBERT H. HALL. J. Milk Tech., *3:* 126–131. 1940.

The training of public employees is recognized as having great value in improving the functioning of any administration. The methods used in New York State are discussed at length and include the training of milk sanitation employees. L.H.B.

278. **Care and Maintenance of Walls.** L. C. THOMSEN. Nat. Butter and Cheese J., *31:* 12, 16. Dec., 1940.

White or light colored walls make the lighting system more effective. Walls and ceilings should be clean and dry and have no air pockets if mold growth and peeling of paint are to be avoided. Condensation of water on cold walls can be eliminated by proper insulation, ventilation and heating. In modern dairy plants glazed tile or brick is being used extensively. W.V.P.

279. **The Application of Wetter Water to Dairy and Milk Plant Use.** F. M. SCALES AND MURIEL KEMP. J. Milk Tech., *3:* 221–227. 1940.

The most important function of any cleansing agent is its wetting ability. A number of compounds have been developed that are very superior in this respect.

A comparative test of a number of these products was made to determine the concentration of each necessary to obtain a wetting time of 10 to 15 seconds by the Draves method at 77° F.

Comparative costs are given of producing 100 gallons of wetting solutions of the different products classified as to their detergent qualities. As the work is considered to be only preliminary the products are designated by letters only; names may be given later when their real qualities have been established.

The tests made comparing wetting times and detergent qualities indicate that "an increase in the length of the carbon chain in the wetting agent im-

proves its detergency at the expense of wetting. The reverse holds true with shortening of the chain. Therefore, with the wetting agents available at present, the best results will, in general, be obtained by choosing a wetting agent with an intermediate wetting time and fairly long carbon chain, or else mixing two such reagents, one with a short carbon chain for wetting, and the other with a long chain to promote detergent action."

None of the common alkali cleaners in a 0.5 per cent solution used in dairy plants were able to even begin to meet the standard of 10 to 15 seconds of wetting time. The actual wetting time was not determined for these compounds; they all were over 2400 seconds. Although mixing certain wetting agents with alkali cleaners will improve the work performed, they still will have the objectionable features of the alkalis (namely requiring considerable labor in brushing surfaces in contact with hot milk; darkening of metal surfaces, spangling and corrosion frequently takes place when hot alkali solutions are used).

The authors conclude that "the examination of the products that make water wetter have shown that there is available for dairy and milk plant cleaning a new group of reagents that will yield better results without harmful effects produced at present. There will also be a saving in time and labor by their use." L.H.B.

280. Eliminating Waste in Our Creameries. L. REDDICK. Can. Dairy and Ice Cream J., *19:* 8, 54. 1940.

The author feels that there is little excuse for wastefulness at any time and asserts that special effort should be made to eliminate it during the present war conditions. Points where waste may be eliminated are: 1. Excessive competition; 2. Frequency of payments to producers; 3. Care in furnishing cans to patrons; 4. Use of washing and cleaning powders; 5. Fuel consumption; 6. Use of labor; and 7. Elimination of poor grade butter. O.F.G.

281. Dairying Statistics of Canada for 1939. P. H. FERGUSON. Can. Dairy and Ice Cr. J., *19:* 8, 44. 1940.

Total milk production for Canada during 1939 was 16,108,450,800 lbs. which was a decrease of 25,401,200 lbs. over the preceding year. The butter production was 371,090,100 lbs. as compared with 372,423,271 lbs. in 1938. The cheese output was 123,818,100 lbs. which was slightly lower than in 1938. The total value of dairy products was estimated at $217,716,029, a 3.7 per cent decrease as compared with the preceding year. O.F.G.

282. Dealer Dynamite. H. H. CURNUTT. Ice Cream Trade J., *37:* 1, 14. 1941.

Make your reputation help you sell, under-promise and over-perform,

cultivate the soil on the other side of the dotted line, make hay while the rain falls, pitch your tent in your customer's camp, be a newsman, not a nuisance; these snappy phrases afford a vehicle used by the author to tell effectively how ice cream salesmen resemble dynamite. The force which they carry around can be a strong, constructive medium, or misapplied it can destroy your business. W.H.M.

283. Methods of Quick Freezing. Tray and Conveyor Freezers for Loose Fruits and Vegetables. Refrigerating Engineering Application Data 22. R. C. WALTHER. Refrig. Eng., *41:* 2. 1941.

The author classifies the freezing of fruits and vegetables under three forms: 1. Barrel freezing; 2. Package freezing; 3. Loose pack; and use of media under six headings, 1. Air, 2. Brine spray, 3. Liquid, 4. Metallic contact with packaged foods, 5. Combinations of above media. These items are described in detail accompanied with diagrams. A diagram of a booster compressor hookup is included. The use of air as the cooling medium is given the most complete treatment. L.M.D.

284. New Observations on Brine Treatment for Corrosion. J. J. JOHNSON. Refrig. Eng., *41:* 2, 103–104. 1941.

In open brine systems, it is recommended that the warm brine return be below the brine surface. Caustic soda should be used for neutralizing brine in preference to lime. The addition of sodium dichromate to brines is strongly recommended in the rate of 1.33 lb. per hundred gallons of calcium brine or 2.66 lb. per hundred gallons of sodium brine when there is no possibility of contaminating food products or contacting workers' hands. Chromating not only prevents corrosion but tends to keep it clear and the cooling surface clean and free from sediment. The pH of brine should be kept at 8.0 or slightly greater. In testing brine for pH with indicators, it should be diluted 50 per cent with freshly boiled distilled water. The following procedure is recommended for checking the pH of a chromated brine: To 25 cc. of the chromated brine add 25 cc. of freshly boiled distilled water and mix thoroughly. Add 2.0 cc. of a 10 per cent barium chloride solution, warm to 75°–100° F. and filter. To 10 cc. of the clear colorless brine in a test tube, add 2–4 drops of B.D.H. Universal indicator, mix, and observe color in a good light. The pH is then estimated from the table on the bottle of indicator solution.

Excess neutralization of brine results in sludge deposits in the cooling system.

In case of a leak of ammonia into the brine, it can be counteracted by use of hydrochloric acid to bring the pH to just below 7.0. Formaldehyde treatment is advocated to "fix" the ammonia and is considered practical up to 0.50 per cent of total ammonia. Six and 392 thousandths lbs. of 36

per cent formaldehyde are used per 100 gallons of brine for each 0.10 per cent of ammonia present. L.M.D.

285. Our Future Markets. J. C. NISBET. Ice Cream Trade J., *37:* 1, 18. 1941.

The price which dairy products can command depends upon the average income and wealth of the consumer who buys the products. In spite of the fact that 131,000,000 Americans have more purchasing power than 1,500,000,000 Asiatics and Europeans, the average milk consumer of America has only $514.00 per year to spend for all products, luxuries, food, clothing, living, etc. If the prices of milk and dairy products are too high the consumer will curtail consumption and the dairyman will suffer. Efficient production on the part of the dairyman and efficient processing and marketing by the plant operators were suggested as essentials for the continued success of the dairy industry. W.H.M.

286. A Philosophy of Management. A. C. ROUTH, JR. Ice Cream Field, *36:* 46, 47. Oct., 1940.

According to the author, management is simply the art of running a business, but we must re-examine its philosophy in terms of "things-as-they-are-going-to-be."

The first job of management is to make other people's work more effective. It is further stated, that there are too many mysteries and too many secrets in the average business. If the facts won't stand the open inspection of the staff there is something wrong with the management, it is claimed.

According to the author, management must assume responsibility for the economic, social and political education of men and women it employs. Management will never again enjoy a concentration of power which will permit it to endure by coercion or caginess. It is claimed that management must reverse its traditional policy of attempting to make a profit by concentrating on ways to get payroll costs down and prices up. The point of view is expressed that management is the paid servant of consumers, labor and stockholders, and if the first groups receive full value the third will automatically benefit.

Management must learn how to give greater value for the money and not figure out ways to raise prices, it is claimed. Good management is primarily a matter of getting things done by intelligent and conscientious attention to details, the author states. The principles outlined have been found by the author to be workable in actual practice and it is claimed that they have been the basis of profitable business operation. W.C.C.

287. The Daily Ever-Balanced Method. J. M. FORBIS. Assn. Bull., Internat. Assn. Milk Dealers, 33rd yr., No. 7, 196–203. Dec., 1940.

A detailed description is given of the steps in the process. With six-

teen clerical workers fifty-five combination routes are handled that average 526 quarts of milk daily plus by-products. Ninety-five per cent of the retail sales are charge. The average sale per customer per year is $60. The cost per year per retail customer is 94 cents for our system of route accounting. Bad debt loss last year amounted to 0.32 per cent. The advantages of the system are that it leaves the routeman more time to spend increasing business and also gives a better connection between the office and the customer through a high type of credit accounting. E.F.G.

288. The Uses of Recordak Equipment. R. J. KISTER. Assn. Bull., Internat. Assn. Milk Dealers., 33rd yr., No. 7, 203–204. Dec., 1940.

The application of the photographic equipment to route accounting facilitates rapid handling of accounts. After photographing, the original route book sheet becomes a statement and is mailed or delivered to the customer at once. E.F.G.

289. A Standing Order System. CHARLES E. HERLIHY, 2nd. The Assn. Bull., Internat. Assn. Milk Dealers, 33rd yr., No. 7, 189–196. Dec., 1940.

This system is described in detail and the forms used are shown. The advantage of this system is that it transfers most of the bookkeeping from the route man to the ledger clerk. This relieves the route man of work which can often be done better by a sub-ledger clerk employed at half the weekly wage rate. The common objections to this system are answered. E.F.G.

290. Present Association Simplified System. JAMES G. RENNIE. The Assn. Bull., Internat. Assn. Milk Dealers, 33rd yr., No. 7, 187–189. Dec., 1940.

Only two forms are needed: 1. The Salesman's Requisition and Load Sheet, and 2. The Salesman's Settlement Sheet. From these two records not only is complete route control possible but cost figures as well. Certain minor changes which have been made in the simplified system are noted. E.F.G.

291. Application of International Electric Accounting Machines to Retail Route Accounting and Related Problems. G. H. BEMIS. The Assn. Bull., Internat. Assn. Milk Dealers, 33rd yr., No. 8, 207–215. Dec., 1940.

Sales of the Crowley Milk Company using this system have increased from 350 to 450 units per route. A punched card file system is used in place of a route book because this saves some time and the file box permits certain

accounting to be done 100 per cent automatically and with mechanical accuracy. This includes the following functions: 1. Balance out the accuracy of the drivers records; 2. Turn out all necessary sales statistics; 3. Prepare the customers' bills. With this system the driver is relieved of certain accounting work which enables more effort to be placed upon sales. The system is described in detail and the various forms and cards needed are illustrated. E.F.G.

292. Our Company's Experience with International Electric Accounting Machines. EDGAR B. PARSONS. The Assn. Bull., Internat. Assn. Milk Dealers, 33rd yr., No. 8, 216–220. Dec., 1940.

Starting with route accounting the puched card system is applied in turn to expense distribution, wholesale billing, automotive and transportation records and milk receipts from producers including writing the checks. Numerous advantages of the system are listed and many operating details are given. E.F.G.

PHYSIOLOGY

293. Mammalian and Avian Assays of Hypophyseal Lactogenic Preparations. WILLIAM R. LYONS. Endocrinology, *28:* 161. 1941.

A comparison of hypophyseal lactogenic hormone preparations was made in pigeons and guinea pigs. The international standard of lactogenic hormone was found to be about one-third as potent as a purified preparation of the lactogenic hormone when compared by either the cropweight response or the minimal crop response in pigeons (Silver King, 4 to 5 weeks from hatching and weighing 400 to 550 gm.). The approximate minimal effective dosage for the international standard was 0.2 to 0.35 mg., for the purified preparation it was 0.06 to 0.12 mg. When guinea pigs were employed as assay animals the international standard was found to be about one-half as potent as purified lactogenic hormone. R.P.R.

294. Evidence for the Presence of a Second Mammogenic (Lobule-Alveolar) Factor in the Anterior Pituitary. J. P. MIXNER, A. A. LEWIS AND C. W. TURNER. Endocrinology, *27:* 888. 1940.

Results are presented which confirm and extend the evidence for the presence of a second mammogenic factor in the anterior pituitary. Anterior pituitary tissue from pregnant cows was administered to 114 ovariectomized mice for periods varying from 4 to 8 days. Dosage ranged from 50 to 200 mg. per mouse. Fifty-seven of the 114 mice showed development of mammary glands to the prelobule stage, *i.e.*, the glands were comparable to those from mice which were pregnant from 4 to 8 days. Evidence was presented which indicates that the lobule-alveolar growth factor is not associated with ether-soluble duct growth extracts of the anterior pituitary. R.P.R.

295. Secretion of Radio-Strontium in Milk of Two Cows Following Intravenous Administration. L. A. Erf and Charles Pecher. Proc. Soc. Exp. Biol. and Med., *45:* 762. 1940.

An attempt was made to determine the rate at which alkaline earth ions in the blood plasma are secreted into milk. Because of a marked similarity in the metabolism of radio-calcium and radio-strontium and because several factors prohibit the use of the former as a tracer in large animals the radio-strontium was used in the experiments. Fifty cc. of an isotonic solution of a mixture of inert and radioactive-strontium lactate (850 mg. of strontium) were given intravenously to each of 2 Holstein cows in the fourth month of lactation and producing about the same quantity of milk. Milk was obtained hourly the first 6 hours after administration and twice a day for the following 4 days. Ashed samples were assayed for radioactivity on a standardized Du Bridge electrometer. Eleven per cent of the dose of radio-strontium administered to the first cow was found in the 34,355 cc. of milk secreted during the first 4¼ days, and 7.88 per cent in the 27,135 cc. of milk secreted by the second cow during the same period. The percentages of the dose found per 100 cc. of milk from the two cows were nearly identical.
R.P.R.

296. Effect of Thyroidectomy upon Sexual Behavior of the Male Bovine. W. E. Petersen, Arless Spielman, B. S. Pomeroy and W. L. Boyd. Proc. Soc. Exp. Biol. and Med., *46:* 16. 1941.

A four-month-old Jersey bull was thyroidectomized and observed for the following 15 months. The animal behaved normally for 60 days following operation. Myxedemic symptoms developed rapidly after that time. Thyroidectomy caused a complete inhibition of libido but had no effect upon spermatogenesis or normality of sperm. The oral administration of 25 gm. of desiccated thyroid over a period of 3 days increased metabolism and restored normal activity and sexual behavior. Similar results were obtained by a single 5 gm. dose of di-nitro phenol. Forty-five mg. of benzedrine sulfate administered orally on each of 4 consecutive days was ineffective. Testosterone propionate pellets (450 mg.) implanted subcutaneously plus 300 mg. of the hormone injected intramuscularly over a period of 13 days improved activity and sexual behavior.
R.P.R.

297. The Regulation of Corpus Luteum Function by Hypophysial Luteotropin. E. B. Astwood. Endocrinology, *28:* 309. 1941.

A method was developed for the assay of hypophysial luteotropin, a substance which maintains the function of formed *corpora lutea.* The mammary glands of 135 hypophysectomized rats treated in various ways were prepared and studied as whole mounts. The combined treatment of gonado-

tropin and estrogen resulted in a considerable extension of the ducts and by the 7th to 8th day, at which time hypophysectomy was performed, the proliferation of end buds had resulted in early lobule formation similar to that seen on the 6th to 8th day of pseudopregnancy or pregnancy. Without further treatment following hypophysectomy there was a prompt regression of the mammary glands within 4 to 6 days. The glands of hypophysectomized rats treated with crude rat placenta extracts continued to proliferate and after 10 days of treatment they were similar to glands of rats pregnant from 12 to 16 days. Whole pituitary powder produced a similar but more marked effect and extensive lobule proliferation was also noted after treatment with a crude luteotropic fraction. Various preparations of crude luteotrophin, however, induced varying amounts of lobule proliferation. The mammary glands of animals injected with the lactogenic–adrenotropin fraction showed little or no proliferation. R.P.R.

298. The Relation of the Thyroid to Mammary Gland Growth in the Rat. SAMUEL L. LEONARD AND RALPH P. REECE. Endocrinology, *28:* 65. 1941.

Thyroidectomy in young female rats resulted in changes in the mammary gland characterized by a thickening of the ducts and an increase in the number of lateral and end buds. Thyroidectomy in spayed rats brought about similar changes when compared with spayed controls. Thyroidectomized spayed rats injected with estrogen showed more extensive mammary development than did spayed rats injected with estrogen. The administration of thyroxin to thyroidectomized rats injected with estrogen tended to prevent the more extensive mammary development. A discussion of the possible mechanism was presented. R.P.R.

299. Inhibition of Mammary Growth by Large Amounts of Estrogen. W. U. GARDNER. Endocrinology, *28:* 53. 1941.

The mammary glands of male mice injected weekly with 50 gamma of estradiol benzoate and estradiol dipropionate until tumors developed or until death occurred were smaller than glands of mice, receiving smaller doses. Mammary growth was nearly completely inhibited by the administration of 50 gamma of estradiol dipropionate. Inhibition of mammary growth in immature or young female monkeys and one male monkey was observed when over 400 gamma of estradiol benzoate were injected weekly for prolonged periods. Little or no mammary growth occurred in 4 young bitches injected weekly with 133 to 533 gamma of estradiol benzoate for long periods and in 3 bitches injected with larger doses for brief periods. The highest incidence of mammary tumors was observed in the estrogen-treated male mice which received doses permitting extensive mammary growth. R.P.R.

300. Retardation of Mammary Involution in Mice by Injection of Lactogenic Hormone. CHARLES W. HOOKER AND W. LANE WILLIAMS. Endocrinology, *28:* 42. 1941.

Twenty-one lactating mice were isolated from their young on the fourth day postpartum. Twelve of these mice were given 7 daily injections of 20 to 60 international units of the lactogenic hormone and 9 were untreated. Compared with the untreated mice, 10 of the mice receiving the lactogenic hormone exhibited definite retardation in mammary involution. The average involution in the treated animals was that of 4 days in contrast to the 7 days of the untreated controls. The lobule-alveolar and duct systems of the injected animals were maintained in a condition very similar to that at parturition. Histological section indicated partial retention of secretory activity. The degree of retardation of mammary involution appeared to be independent of the dose used and ovariectomy was without influence upon the regression in the treated mice. R.P.R.

301. Tissue Ascorbic Acid in Hypophysectomized Rats. DONALD E. BOWMAN, LUCIEN E. MORRIS, AND JOHN R. STACY. Proc. Soc. Exp. Biol. and Med., *45:* 785. 1940.

Tissue ascorbic acid was estimated by titrating a metaphosphoric acid extract of the tissues with 2, 6-dichlorophenol indophenol. The tissue ascorbic acid values in 5 hypophysectomized rats were definitely below normal. The average values (mg. per 100 gm. of tissue) for 5 hypophysectomized and 5 normal rats were, respectively, as follows: liver, 8.4, 23.2; kidney, 6.5, 15.2; adrenal, 160.8, 340; and small intestine, 4.8, 21.2. R.P.R.

302. Growth of the Mammary Glands in Hypophysectomized Mice. W. U. GARDNER. Proc. Soc. Exp. Biol. and Med., *45:* 835. 1940.

Of one hundred one hybrid mice which were hypophysectomized when they were from 30 to 80 days old 65 were found completely hypophysectomized as revealed by examination of serial sections of the sella turcica and surrounding tissues. Slight growth of the mammary glands was induced within 15 days in 2 out of 7 mice injected with desoxycorticosterone, in 1 out of 4 mice injected with progesterone, and in 5 out of 10 mice injected with estradiol dipropionate. The glands of the incompletely operated mice receiving these 3 hormones were more extensively developed if anterior lobe tissue remained. Extensive and rapid proliferation of the mammary ducts occurred in 12 out of 14 completely hypophysectomized mice injected with desoxycorticosterone plus estradiol dipropionate and in 11 out of 12 animals injected with progesterone plus estradiol dipropionate. Testosterone propionate either alone or in combination with estradiol dipropionate produced no mammary growth in 18 completely hypophysectomized mice. R.P.R.

303. Studies on Pituitary Lactogenic Hormone. III. Solubilities of Sheep and Beef Hormones. CHOH HAO LI, WILLIAM R. LYONS, AND HERBERT M. EVANS. J. Gen. Physiol., *24:* 303–309. 1941.

Solubility studies constitute the best available method for determining homogeneity of a protein, especially if they are carried out with a variety of solvents. Although it has not been possible to secure the pituitary lactogenic hormone in a uniform crystalline state, in electrophoresis experiments it behaves as a single substance.

The salting-out effect of NaCl in acid solution of both beef and sheep hormones has been studied at room temperature. In these studies both preparations behaved as pure substances, but they exhibited differences in solubility, thus indicating a species specificity. D.E.

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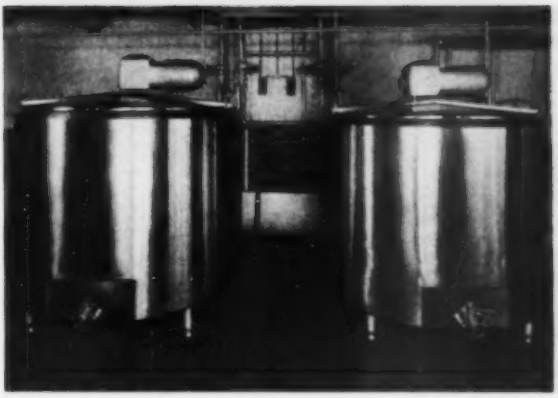

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A Carotene, Pro-Vitamin A Product for Enriching Ice Cream

Provalac supplies the thoroughly palatable, fruit and vegetable form of vitamin A activity. It is available at nominal cost—no royalties or license fees to pay. No extra equipment to buy.

It makes possible a definite minimum vitamin A content the year 'round—provides "June" cream color without certified coloring.

You are invited to write for further details and samples of Provalac for test purposes.

General Biochemicals, Incorporated
35 Laboratory Park Chagrin Falls, Ohio

MARSCHALL RENNET

Is a dependable coagulant for the cheese manufacturer. Careful laboratory control assures the strength, purity and uniformity of MARSCHALL'S all the time.

Liberal samples of Marschall Rennet and Cheese Color may be had for the asking.

Marschall Dairy Laboratory
Incorporated
Madison, Wisconsin

THE COMPOUNDING OF FINE VANILLA FLAVORING *IS AN* ART

The leadership of Mixevan for quality is the result of over 30 years specialized experience. Its uniform character is achieved through expert knowledge, individual selection of beans, extra development of the bouquet, intricate compounding and special grinding technique . . . *It is the ultimate in fine flavoring for dairy products.*

MICHAEL'S MIXEVAN
AMERICA'S FLAVORITE
MADE FROM BOURBON AND MEXICAN VANILLA BEAN, VANILLIN AND SUGAR
EXPERTLY BLENDED AND PROCESSED TO PRODUCE A DELIGHTFUL MELLOW FULL FLAVOR
DAVID MICHAEL & CO.
VANILLA PRODUCTS
FRONT AND MASTER STS.
PHILADELPHIA

Your advertisement is being read in every State and in 25 Foreign Countries

DIVERSEY
NOVEX
THE PERFECTED CAN CLEANER
A CAN WASHING COMPOUND THAT MEETS ALL REQUIREMENTS
REPORT FROM THE DIVERSEY RESEARCH LABORATORY

CAN washing until recently has been the orphan of the dairy industry. Little attention was given the cleaning compound employed . . . until clogged nozzles rendered the washer practically useless, and spangled or badly corroded cans shouted for attention. Diversey's research laboratory was among the first to appreciate the importance of the problem . . . made many plant tests to determine the exact requirements of the "perfect" can washing compound . . . then proceeded to develop a product that fully met these requirements. The result is Diversey NOVEX, a powerful, 100% active cleaner that consistently delivers thoroughly cleaned, sweet-smelling cans . . . free from corrosion or spangling . . . while keeping the washer at peak operating efficiency.

For information on *better can washing* write—

THE DIVERSEY CORPORATION
53 W. Jackson Blvd., Chicago, Ill.

DIVERSEY SERVICE *plus* RESEARCH *teamed* FOR DAIRY SANITATION

FLAV-O-LAC FLAKES

THE CULTURE
of definitely better flavor & aroma-producing qualities.

The standard with foremost operators, agricultural schools & colleges.

FLAV-O-LAC FLAKES (shown) produce a quart of the finest starter on a single propagation. Single bottles $2.00.

SPECIAL FLAV-O-LAC FLAKES "40" produce 40 quarts of starter on a single propagation. Single bottles $3.00.

Our cultures are safely shipped to all parts of the world. Money back guarantee. Send for our free culture manual.

THE
DAIRY LABORATORIES
Dept. J-41, Phila., Pa.

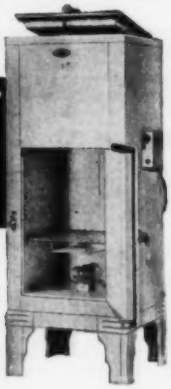
DALARE ASSOCIATES

BRANCHES
New York Baltimore Washington

See our catalog in Dairy Industries Catalog.

STARTERMAKERS:

"HANSEN'S" CULTURE CABINET



assures you

ACCURATE TEMPERATURE CONTROL

Here is a cabinet that will provide you with all the advantages of equipment costing several times the price of this unit. It is Reliable—Easy to Operate—Sturdy—Low in Cost!

only
$37.50
complete
• • •
FREE
12 Bottles of "Hansen's" Liquid Lactic Ferment Culture with every Culture Cabinet.

Chr. Hansen's Laboratory, Inc.
Milwaukee • Wisconsin

Your advertisement is being read in every State and in 25 Foreign Countries

JUST TO REMIND YOU!

Clean Cans Are Vital to a Quality Product

C P Straightaway and Rotary Can Washers Are Engineered to Assure a QUALITY-PROTECTING Washing and Drying Job.

In considering ways and means for quality improvement, don't overlook the receiving room. Right there may be the place to begin.

Clean cans are vital to a quality product. We suggest you check up on your equipment and methods. If you have a can washer in good condition, go over it to see that it operates at top efficiency, temperatures right, volume right, cans come off clean and dry. Some overhauling and reconditioning may be in order. But if your washer falls down on the job because of poor design or because it is overworked or worn out or if perchance you still wash cans by hand, then you *do* need a new washer.

We make can washers of both the straightaway and rotary types. They are all good machines. One of them will fit your needs. Check up on your can washing equipment and methods. If you are not fully satisfied with your present results, call in the CP Man or write nearest branch office.

THE CREAMERY PACKAGE MFG. COMPANY

1243 West Washington Boulevard - - - - Chicago, Illinois

Sales Branches in 18 Principal Cities

Your advertisement is being read in every State and in 25 Foreign Countries

DIFCO

Ingredients of

TRYPTONE GLUCOSE EXTRACT MILK AGAR

The American Public Health Association, in its "Standard Methods for the Examination of Dairy Products," recommends the use of Tryptone Glucose Extract Milk Agar for total plate counts of bacteria in milk. For the preparation of this medium the use of Bacto-Tryptone and Bacto-Beef Extract is specified.

BACTO–TRYPTONE is an excellent nutriment for use in culture media designed for propagation of bacteria in milk. Luxuriant growth of these organisms occurs readily on plates of the standard medium prepared with this peptone.

BACTO–BEEF EXTRACT is tested and standardized for use in preparation of culture media. In the concentrations employed in Tryptone Glucose Extract Milk Agar it is sparklingly clear and has a reaction of pH 6.8.

Standard Tryptone Glucose Extract Milk Agar may be prepared from Bacto-Tryptone and Bacto-Beef Extract by combining them with Bacto-Dextrose and Bacto-Agar. No adjustment of reaction is necessary because after autoclave sterilization the medium will have a reaction of pH 7.0. The complete dehydrated medium, Bacto-Tryptone Glucose Extract Agar, is also available.

BACTO–SKIM MILK, prepared in a 10 per cent concentration, is recommended for addition to the medium when milk dilutions greater than 1 to 10 are plated.

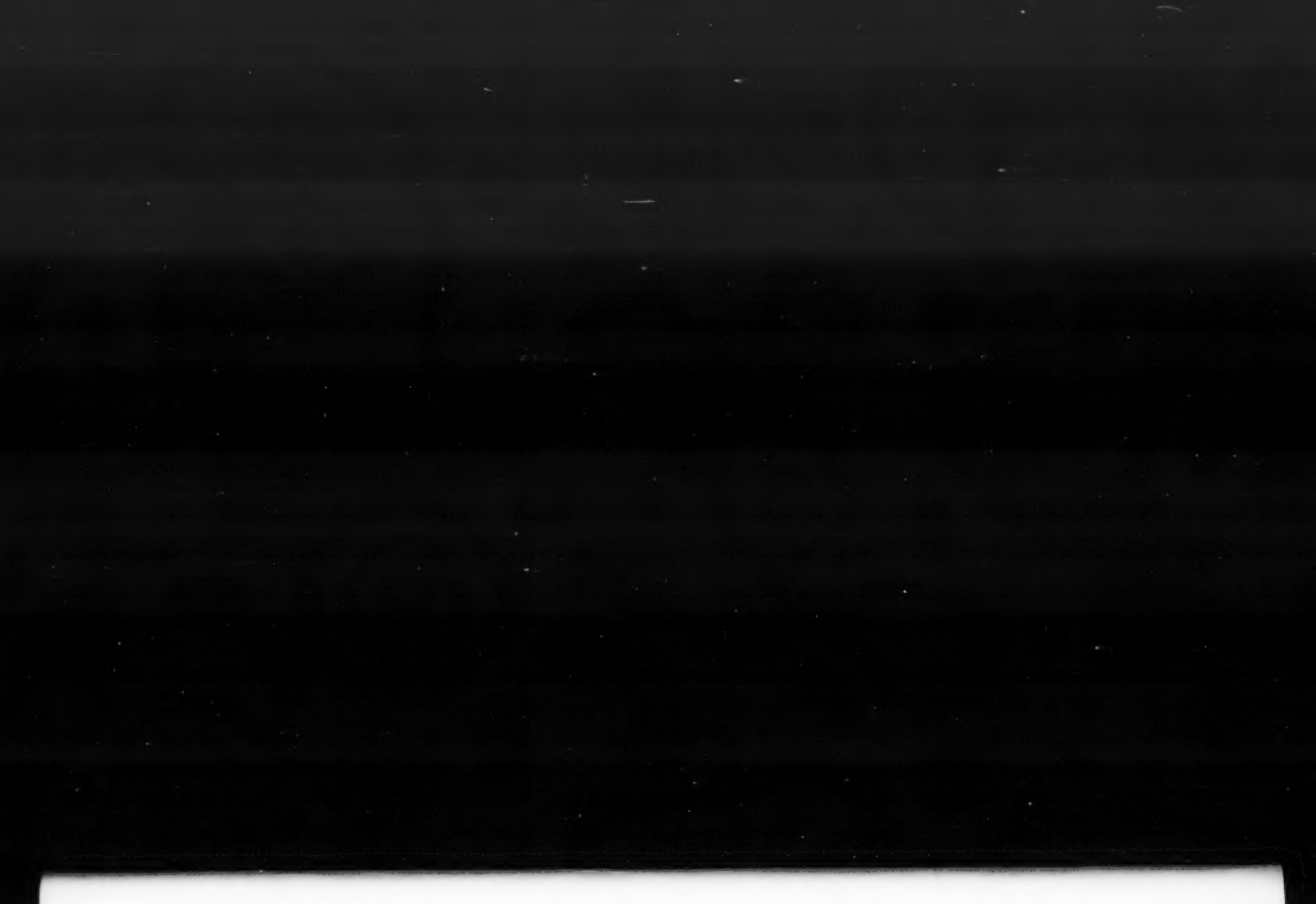
Specify "DIFCO"

THE TRADE NAME OF THE PIONEERS

In the Research and Development of Bacto-Peptone and Dehydrated Culture Media

DIFCO LABORATORIES

INCORPORATED

DETROIT, MICHIGAN

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